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Instruction Book

POLYSKOP

Type SWOB

BN 4244/50

BN 4244/60

BN 4244/75

R 7957
1062
Bl. 1
(118 Bl.)

Note: Always quote the Type and Order Number (BN) in addition to the Serial Number (FNr.) of the set when asking for technical information and, in particular, when ordering repair parts.

Edition R 7957/1062

Table of Contents

Page

<u>1.</u>	<u>What is the POLYSKOP</u>	6
1.1	Short General Description	6
1.2	Technical Data of the POLYSKOP	8
<u>2.</u>	<u>Operating Instructions for the POLYSKOP</u>	10
2.1	Preparation for Use	10
2.2	Functional Check, Short-circuit Measurement	10
2.2.1	Checking the EMF	10
2.2.2	Measurement of the Output Voltage (E_{out})	11
2.2.3	Measurement of the Short-circuit Frequency Response	12
2.2.4	Display of Two Voltage Variables	12
2.3	Adjustment of Sweep Width	13
2.4	Applying an External Marker	13
2.5	Modulation Input	13
2.6	Measuring with the RF Diode Probe	14
2.7	Investigations on Test Items with Built-in Rectifiers	14
2.8	Response Amplitude Measurements	15
<u>3.</u>	<u>Examples of Application</u>	17
3.1	Measurement of a Single Tuned Circuit	17
3.1.1	Connecting the Signal Generator of the Polyskop to the Test Item	17
3.1.2	Measuring the Resonance Frequency	17
3.1.3	Measuring the Q of a Tuned Circuit	18
3.1.4	Possibility of Measuring Errors	18
3.2	Measurements on Bandpass Filter	18
3.2.1	Test Setup	20
3.2.2	Measuring the Bandwidth	20
3.2.3	Adjusting the Coefficient of Coupling of a Bandpass Filter	20
3.2.4	Possibility of Measuring Errors	20
3.2.5	Measuring and Aligning Multistage IF Amplifiers	22
3.3	Limiters and Discriminators	22
3.3.1	Limiters	22
3.3.2	Discriminators	22
3.3.3	Possibility of Measuring Errors	23
3.4	Filter Alignment	24

R 7957
1062
Bl. 2

	Page
3.4.1 Connecting the Test Item	24
3.4.2 Measurements	25
3.4.3 Interpretation of the Measurement Results	25
3.4.4 Filter Adjustment Against a Standard	25
3.4.5 Possibility of Measuring Errors	25
3.5 Measuring the Gain of an Amplifier Stage	26
3.6 Video and Distributed Amplifiers	26
3.6.1 Possibility of Measuring Errors	27
3.7 Determining the Frequency of a Signal Source	27
3.7.1 Method of Measurement	27
3.7.2 Test Setup	27
3.8 Checking the Frequency Calibration on Receivers	28
3.9 Alignment of Television Receiver Components	29
3.10 Measurements on Multicouplers	29
3.11 Locating Bad Earthing Conditions	29
3.11.1 Test Setup	29
3.11.2 Possibility of Measuring Errors	30
3.12 Measurements on Cables, Cable Connectors and Termination Impedances	30
3.12.1 Measuring Technique and Test Setup	32
3.12.2 Determination of the Characteristic Impedance Z_0	32
3.12.3 Determining the Dielectric Constant	33
3.12.4 Determining Cable Attenuation	34
3.12.5 Determining the Homogeneity	34
3.12.6 Measuring with a Mismatched Cable	35
3.12.7 Determining the Phase Angle of the Reflection Coefficient	39
3.12.8 Possibilities of Measuring Errors	39
<u>4. How to Avoid Measuring Errors</u>	<u>40</u>
4.1 Measuring Errors Caused by Using an Excessive Sweep Width	41
4.2 Overdriving the Test Item	41
4.3 Measuring Errors Caused by Distortion	41
4.4 Hum and RF Pickup	42
4.5 Measuring Errors Caused by Overdriving the Vertical Deflec- tion Amplifier	42
4.6 Measuring Errors Caused by Oscillator Pickup	43
4.7 The POLYSKOP is not Suitable for the Following Measurements	43

R 7957
1062
Bl. 3

<u>Index for Circuit Description</u>	44
<u>5. Circuit Description</u>	46
5.1 Signal Generator Section	46
5.2 Display Section	53
5.3 The Marker Generator	58
5.4 Power Supply	59
<u>6. Specifications</u>	63
6.1 Sweep Signal Generator	63
6.2 Display Section	64
6.3 Picture Tube Assembly	65
6.4 Common Data	66
6.5 Accessories	67
6.6 Recommended Accessories	67
<u>7. Maintenance of the POLYSKOP</u>	69
7.1 Picture Tube	69
7.2 Replacing the Picture Tube	69
7.3 Adjusting the Ion-trap Magnet	70
7.4 Adjusting the Display Position	70
7.5 Adjusting the Focus Coil	70
7.6 Replacing the Valves in the POLYSKOP	71
7.7 Replacing the Transistors	71
7.8 Replacing the Graticule Illumination Lamps	71
7.9 Replacing and Cleaning the Graticule	72
7.10 Hints for Proper Operation	72
7.10.1 Operation from Low AC Supply Voltage	72
7.10.2 Overloading the Oscillator Valves	72
<u>8. Repairing the POLYSKOP</u>	73
8.1 Adjusting the Regulated Anode Supply Voltage	73
8.2 Adjusting the Regulated Heater Voltage	73
8.3 Testing the Voltage Values	73
8.4 RF Oscillators	73
8.5 Setting the RF Output Voltage	74
8.6 Replacing the Measuring Diodes	74

R 7957
1062
Bl. 4

	Page
8.6.1 Control Diode	74
8.6.2 Diodes Located in the RF Output and RF Input Measuring Heads	74
8.7 O-Reference Line Adjustment	75
8.8 Equal Display Amplitudes for Positive or Negative Signals . .	76
8.9 Marker Generator	76
8.10 Adjusting the Display Width	76
8.11 Adjusting the Keying Phase	76
8.12 Adjustment of the Sweep-Width Linearity	77
 <u>9. The Fundamentals of the Sweep Frequency Method with its Limitations</u>	 80
9.1 Introduction	80
9.2 Sine-wave Frequency Sweep	82
9.3 Detection and Indication of the Measured Values	85
9.4 Diode Detectors and Vertical-Deflection Amplifiers with In- adequate Bandwidths	86
9.5 Effect of an Excessive Sweep Rate upon the Measurements . . .	86
9.6 Effect of Distortion in the Measuring Signal upon the Meas- urements	88
9.7 Behaviour of Diodes Measuring Signals containing Distortion .	90
 <u>10. Photographing the Display on the POLYSKOP</u>	 91
 <u>11. References</u>	 92
 <u>12. Table of Replaceable Parts of the Type SWOB</u>	 93
 <u>Guarantee</u>	 116
 <u>Circuit Diagram and Table of Replaceable Parts for RF Diode Probe</u> . .	 117
 <u>Circuit Diagram for Type SWOB</u>	 118

R 7957
1062
Bl. 5

1. What is the POLYSKOP

1.1 Short General Description (see Fig. 1)

The POLYSKOP is a practical test set which combines in a single instrument the individual pieces of test equipment needed for exact voltage/frequency measurements. The frequency range extends from 500 kc to 400 Mc. The pictorial diagram of Fig. 1 shows a measurement being made with and without the POLYSKOP. From this diagram you can readily see the conveniences that the POLYSKOP will offer you. The POLYSKOP combines the following pieces of equipment:

A S i g n a l G e n e r a t o r with the frequency range extending from 500 kc to 400 Mc, whose EMF must be held constant throughout the entire frequency range ...

The signal generator incorporated in the POLYSKOP offers the great advantage that the tedious work required to keep the EMF at a constant value is done by an automatic control circuit.

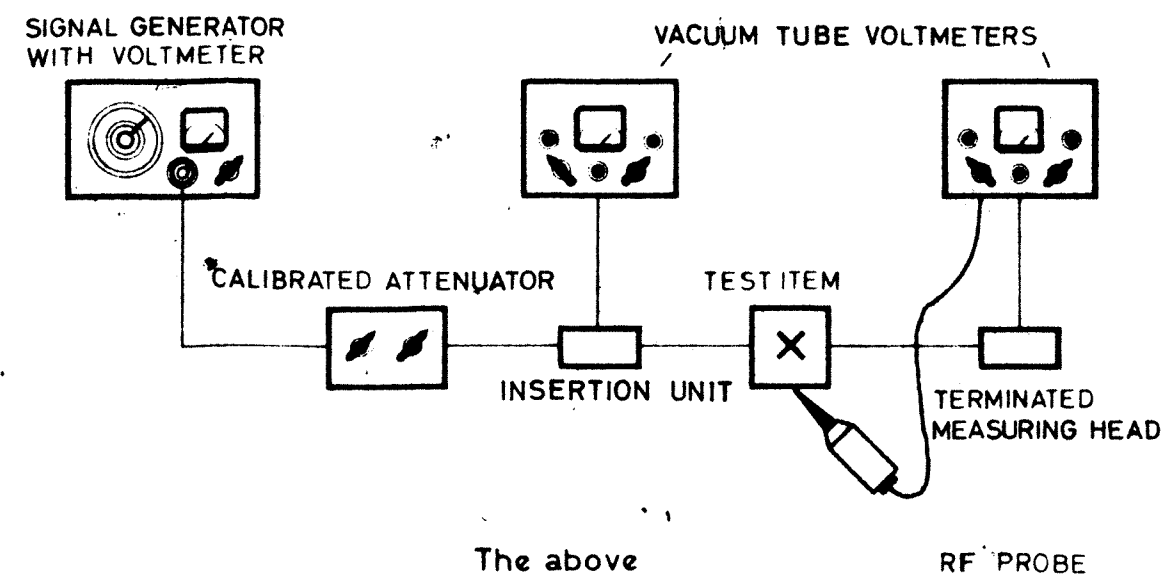
A C a l i b r a t e d A t t e n u a t o r , with the help of which you can set the desired signal-generator output voltage

This attenuator of the POLYSKOP permits the voltage to be varied in 1-db and 10-db steps between 0 and -70 db (0 db referred to $0.5 V_{rms}$).

A V a c u u m - t u b e V o l t m e t e r which measures the test-item input voltage as a function of frequency by means of a diode in an insertion unit . .

is also incorporated in the POLYSKOP, which makes it possible to avoid many sources of error caused by the manner in which the test item is connected.

A V a c u u m - t u b e V o l t m e t e r in conjunction with a terminated measuring head or an RF probe, which indicates the voltage as a function of frequency at the output of the test item



The above
TEST SET-UP
consisting of

- several signal generators for the entire range from 0.5 to 400 Mc,
- a calibrated attenuator,
- a vacuum-tube voltmeter with an insertion unit
- and a vacuum-tube voltmeter with a terminated measuring head or diode probe

is replaced by
one single instrument

POLYSKOP

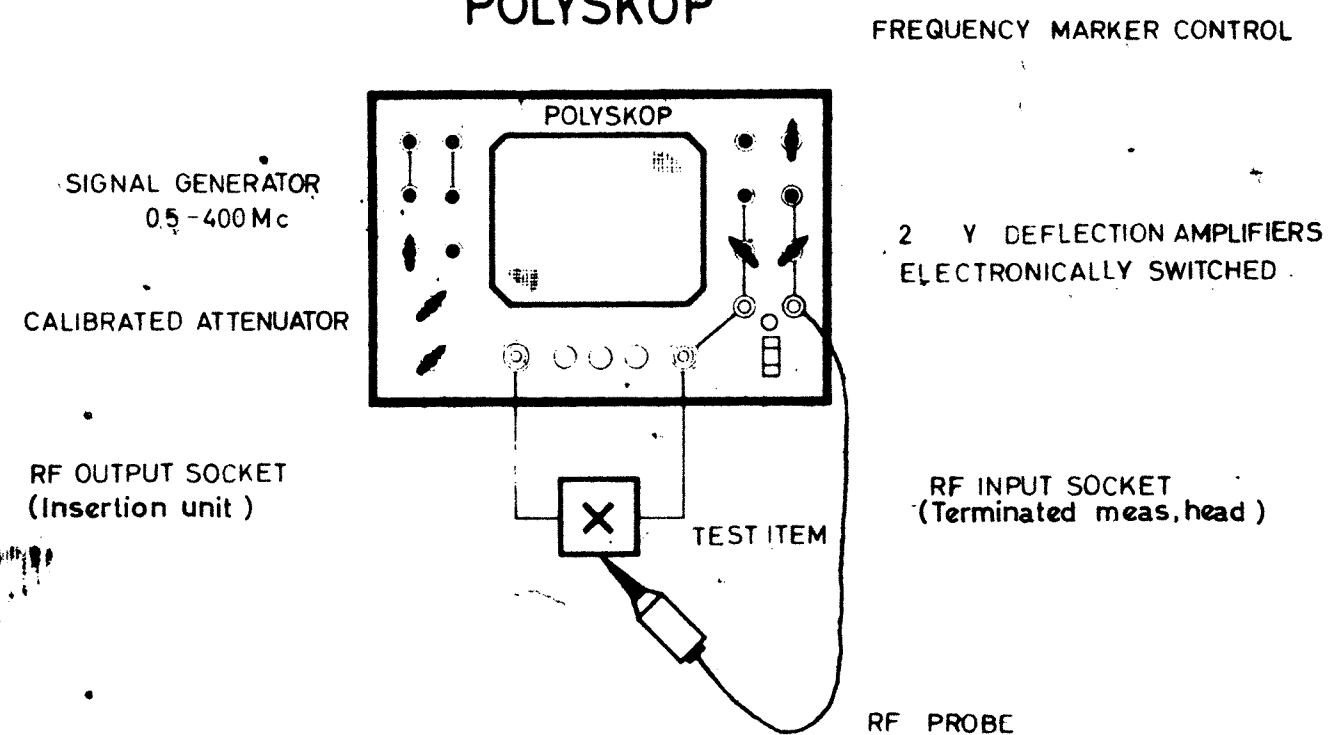


Fig 1

is also contained in the POLYSKOP, the measuring sensitivity lying far above that of a normal broad-band VTVM.

Finally, the POLYSKOP contains various F r e q u e n - c y M a r k e r s , which are useful for many other purposes besides the exact measurement of frequency.

Everything that you need for the accomplishment of exact measurements in the high- and video-frequency ranges is built into the POLYSKOP. In addition, the POLYSKOP automatically displays t w o v a r i a b l e s at the same time on a large picture screen. With the POLYSKOP, you are able to do many measurements in a fraction of the time necessary for point-by-point methods, and the results are just as accurate as those obtained from a test setup put together with considerable effort.

Sections 3. and 4. of this instruction book are devoted to the question of how you can recognize measurement errors and avoid them. Also mentioned are measurements for which the POLYSKOP is unsuited. Finally, we recommend that you read over the fundamentals of sweep-frequency measurements found in section 9. of this instruction book where everything worth knowing is consolidated. This will make it easy for you to apply the POLYSKOP successfully to your problem.

1.2 Technical Data of the POLYSKOP (see Fig. 2)

In Fig. 2 you will find the technical data of the POLYSKOP as well as the locations of the outer connections and control knobs. Sections 5. and 6. contain further information on the technical characteristics and the recommended accessories.

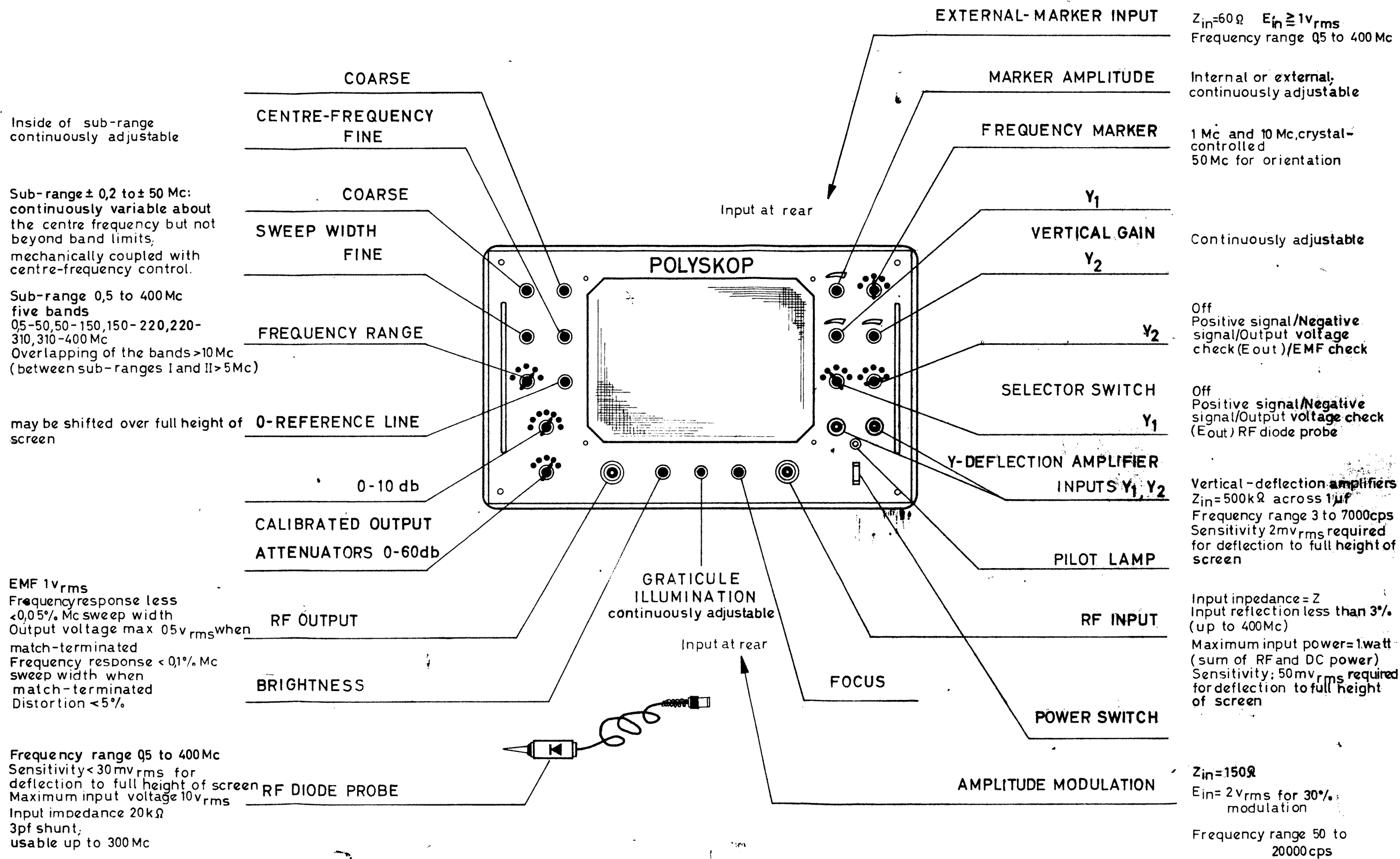


Fig.2 Technical data of the POLYSKOP

2. Operating Instructions for the POLYSKOP

2.1 Preparation for Use

The POLYSKOP Type SWOB leaves our factory adjusted for operation from 220 v AC. To adjust it for 115 v, 125 v or 235 v, remove the chassis from its cabinet and insert the proper fuse into the clips marked on the fuse panel to correspond with the local AC supply voltage. The fuse panel is located above the power transformer. The fuse rating is 2 amperes for 115 v and 125 v; for 220 v and 235 v, it is 1 ampere.

Plug the power cord LK 333 supplied with the set into the receptacle at the rear of the POLYSKOP. The positions of the control knobs and connections can be seen from Fig. 5.

Put the power switch (14) up for onwards. The pilot lamp (15) indicates that voltage is applied to the set. Allow one minute for warming up and turn the BRIGHTNESS control clockwise until the horizontal 0-reference line appears on the screen. Adjust the FOCUS control (12) for minimum thickness of the trace. Until the set is completely warmed up, it is necessary to readjust the FOCUS control several times. Vertical positioning of the 0-reference line is possible with the 0-LINE control (6). Normally, this line is brought to coincidence with the engraved zero line of the graticule. Should the 0-reference line be slanted, please read sections 7. and 8., "Maintenance and Repair".

2.2 Functional Check, Short-circuit Measurement

We recommend that the POLYSKOP be checked for proper operation by means of a short-circuit measurement before putting the set into use.

2.2.1 Checking the EMF

The EMF of the built-in signal generator is held constant with the aid of an automatic control circuit. It is possible to make the following check to convince yourself that the EMF exhibits no frequency response:

- (1) Set the OUTPUT ATTENUATOR (8) to at least 40 db.
- (2) Turn the Y_1 selector switch (18) to its position "OFF".
- (3) Turn the Y_2 selector switch (19) to its position "EMF".
- (4) Advance the Y_2 gain control (20) until the EMF curve is displayed.

With maximum sweep width (SWEEP WIDTH controls ③ and ④ turned completely clockwise) and the CENTRE FREQUENCY controls ① and ② placed in their middle positions, the EMF curve should not exhibit any noticeable frequency response⁺ in any of the five ranges of the POLYSKOP. The two horizontal lines shown in Fig. 3 are visible in the frequency range between 50 and 400 Mc. During the flyback period, the RF oscillators are keyed off so that the 0-reference line is seen.

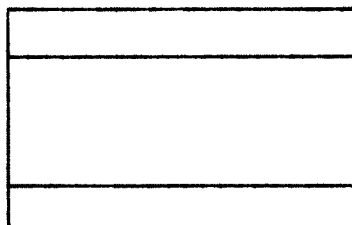


Fig. 3

In the frequency range 0.5 to 50 Mc, the display appears somewhat different (see Fig. 4). The sharp break at the left-hand side is caused by the lower limit frequency at 0.5 Mc; the fall-off at the right-hand side is caused by the upper limit frequency at approx. 55 Mc.

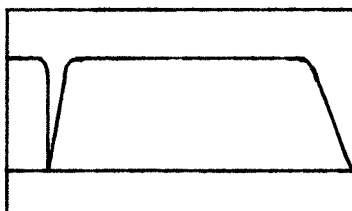


Fig. 4

By manipulating the CENTRE FREQUENCY ① - ② and the SWEEP WIDTH ③ - ④ controls you can obtain any desired frequency sub-range within the specified frequency limits. The coarse controls for the centre frequency ② and the sweep width ③ are mechanically coupled together in such a manner that an erroneous adjustment is not possible. Depending upon the adjusted amount of sweep width, the tuning range of the centre frequency is reduced so that exceeding the range limits - governed by the sweeping technique used in the POLYSKOP - is not possible.

2.2.2 Measurement of the Output Voltage (E_{out})

First terminate the POLYSKOP RF output ⑨ with a good resistor such as our UHF Standard Resistors Type RMD. Next switch the OUTPUT ATTENUATOR ⑦ - ⑧ to 0 DB and place one of the two selector switches ⑮ or ⑯ in the position "E_{OUT}". No substantial frequency response should be rec-

⁺ less than 0.1%/Mc sweep width

ognizable even though an absolute agreement between the E_{out} -indication and the EMF cannot be expected, since certain sources of error in the attenuators and cable connections are unavoidable. For this reason, you will find discrepancies in the tolerance given for the "Flatness of Output Level" in the Specifications. If you measure the POLYSKOP output voltage with the OUTPUT ATTENUATOR placed at -20 db, you will recognize a certain amount of fluctuation in the indication, especially in the range 0.5 to 50 Mc. This is caused by the small distortion of up to 5% present in the POLYSKOP signal generator output. Diode detector arrangements, which are also used in the POLYSKOP for indication, respond strongly to distortion in the measured signal. For particulars, please read paragraphs 4.3 and 9.6.

2.2.3 Measurement of the Short-circuit Frequency Response

With the measurements carried out according to the paragraphs 2.2.1 and 2.2.2, you have checked the proper functioning of the signal-generator section of the POLYSKOP. Only the proper functioning of the RF INPUT SOCKET containing the diode detector for the response indications remains to be checked. The following procedure should be followed in making this check:

Connect the RF OUTPUT (9) to the RF INPUT (13) with a good cable (such a cable is supplied with the POLYSKOP). Place the selector switch Y_1 , (18), in the position "RF" and the OUTPUT ATTENUATOR in the position "0 DB". The deviation of the frequency response curve should not be more than 5%. With reduced signal-generator voltage (for example, -20 db), the deviation may be larger for the reasons given in detail in paragraph 2.2.2.

2.2.4 Display of Two Voltage Variables

If both selector switches (18) and (19) are put to a position other than OFF, the voltage variables applied to the Y_1 and Y_2 amplifiers are written alternately at one half the AC supply frequency. A built-in electronic switch makes the switch-overs, displaying both voltage variables simultaneously on the picture screen. The electronic switch is shut off if one of the selector switches is placed in the position OFF, the writing frequency then becoming equal to the AC supply frequency (48 - 62 cps).

2.3 Adjustment of Sweep Width

For example, a sweep width from 210 Mc to 216 Mc is desired. The following procedure is recommended:

- (1) Select the 150-220 Mc band and the 50-Mc frequency markers.
- (2) Turn the SWEEP WIDTH control completely clockwise. Notice the two markers in the display, the left one at 150 Mc and the right one at 200 Mc.
- (3) Bring the 200-Mc marker to the left-hand side of the display by decreasing the sweep width with the SWEEP WIDTH control and manipulating the coarse CENTRE FREQUENCY control (2).
- (4) Switch on the 10-Mc marker spectrum and locate the marker for 200 Mc, 210 Mc and 220 Mc, respectively.
- (5) Bring the 210-Mc marker to the left-hand and the 220-Mc marker to the right-hand side of the display by further decreasing the sweep width.
- (6) Switch on the 1-Mc marker spectrum.

With repeated manipulations of the fine SWEEP WIDTH (4) and CENTRE FREQUENCY (1) controls, the frequency sweep between 210 Mc and 216 Mc may be displayed across the picture-tube screen.

2.4 Applying an External Marker

A signal generator which delivers approx. 1 v_{rms} across 60 Ω at the desired marker frequency is necessary for applying an external marker to the POLYSKOP. The signal generator output voltage is applied to the rear R&S Dezifix connector of the POLYSKOP. The frequency marker is adjusted to the desired display height using control (23). With the FREQUENCY MARKER switch (22) placed in position EXT, only the external marker is visible. In the positions 1, 10 or 50 Mc, the external marker appears with the internal marker.

2.5 Modulation Input

It is possible to amplitude-modulate the POLYSKOP RF output voltage. The necessary signal voltage input connection is located at the rear of the set. The POLYSKOP may be amplitude-modulated up to an upper frequency limit of 20 kc.

However, it must be noted that when making a short-circuit check or other measurements using the POLYSKOP vertical-deflection amplifier, the frequencies over 7 kc do not appear at the full display height since this amplifier has an amplitude response only up to 7 kc.

2.6 Measuring with the RF Diode Probe

The two RF diode probes supplied with the POLYSKOP are characterized by a small input capacitance and a high sensitivity. RF voltages of a few millivolts can be displayed at full height on the screen of the POLYSKOP. However, you must take care to ensure that a good earth connection is made to the probe shell as close as possible to the point of measuring. The two replaceable probe tips are not meant to be soldered to the check point since the trolitul disk in the diode probe would be damaged. In order to solder the diode probe to the circuit under test, unscrew the probe tip and fasten a soldering lug to the diode probe with a suitable screw. The diode probes are safe for DC voltages up to 500 v and operate as a voltage-doubler.

The RF probe marked by a red ring has one side of the rectifier circuit connected to the probe shell through a capacitance. This probe is less sensitive with reference to hum pickup. However, there are cases, depending upon the test setup, where the RF earthing conditions are not defined. This is recognized by the fact that the indications change when the RF probe is touched or moved about. These instable indications cannot be tolerated under any circumstances since they indicate a measuring error. In these cases, try using the RF probe not marked with a red ring. This probe has its rectifier circuit connected directly to its shell which, in turn, is connected to the cable shield. Further information as to how you can recognize and avoid measuring errors can be found in section 4.

2.7 Investigations on Test Items with Built-in Rectifiers

In most cases, receivers and intermediate-frequency amplifiers contain rectifiers for the demodulation of the RF voltages. It is possible to feed a demodulated voltage directly from the test item to the input of one of the vertical-deflection amplifiers. Loading effects on a demodulator circuit remain quite small if an isolating resistance of 100 k Ω is placed between

the check point and the input of the vertical-deflection amplifier. It is also recommended that a shielded cable be used for the connection between the test item and amplifier input. If the test item has an amplifier stage following its demodulator, the POLYSKOP may be connected to this amplifier only if its pass band extends down to at least 1 cps. This condition is practically never met so that in general the POLYSKOP should be connected directly to the demodulating circuit of the test item if errors are to be avoided.

Depending upon the polarity of the voltage taken from the demodulator circuit, the selector switch (18) or (19) is placed in the position "POS" or "NEG": The vertical-deflection amplifier inputs (16) and (17) of the POLYSKOP are safe for DC voltages up to 500 v.

2.8 Response Amplitude Measurements

The exact response voltage amplitude c a n n o t be read from the picture-tube graticule.

Diode rectifier arrangements such as those used in the RF input (terminated measuring head) and the test probes are inherently non-linear elements. At low RF voltage levels, the relationship between the RF voltage and the rectified diode current is particularly non-linear. It was therefore not possible to provide the plexiglass picture-tube protector with a db-calibrated scale. For this reason, the amplitude measurements must be made indirectly by the comparison of voltage level changes of the signal-generator output voltage. This method ensures that the non-linearity of the diode used for rectification, even if contained in the test item, does not affect the measuring accuracy. A further advantage of the indirect method of measurement lies in the fact that overdriving of the test item is immediately recognizable.

The built-in attenuators (7) and (8) provide defined level drops down to -70 db in steps of 1 db. With the gain of the vertical deflection amplifiers left constant, it is possible to determine the position of the horizontal trace on the display which corresponds to a given level drop as read from the adjusted attenuators. The response curve of the EMF can be used conveniently as a reference line to mark the determined level.

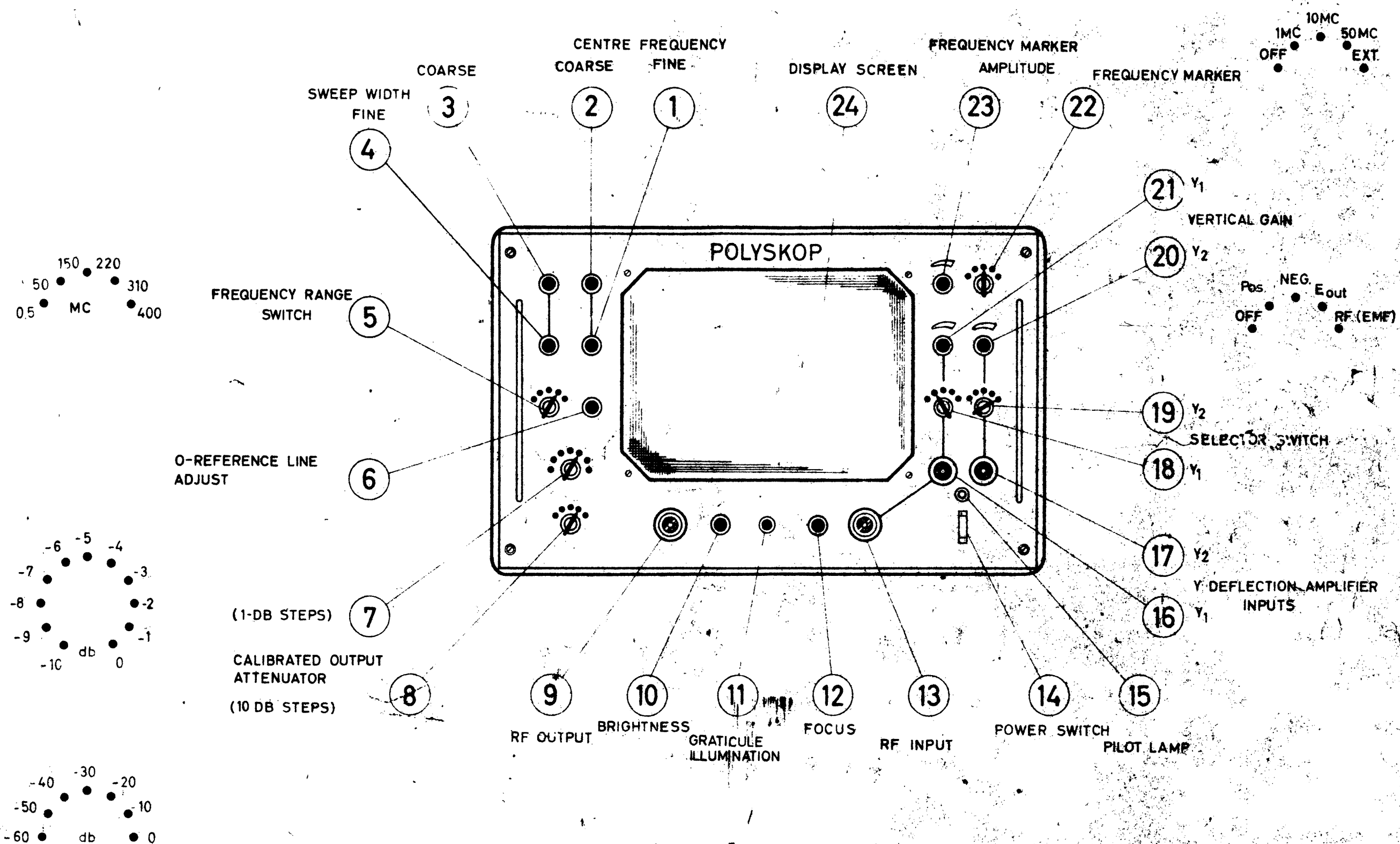


Fig.5 Front Panel Controls

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3. Examples of Application

3.1 Measurement of a Single Tuned Circuit (resonance frequency and bandwidth)

Single tuned circuits, which are used as coupling network between two amplifier stages, are best investigated with a test setup as shown in Fig. 6.

3.1.1 Connecting the Signal Generator of the Polyskop to the Test Item

For this purpose, use a cable, which is not too long, with an open end that can be soldered to the grid of the first amplifier stage. With such makeshift connections, you must take care to ensure that a good impedance match is made. To make certain of this, use one of the beams to trace the output voltage E_{out} as a function of frequency while the other beam is used for the test results.

The fluctuation of E_{out} must not vary more than 20% in the frequency range used for measuring. If these fluctuations are greater than 20%, it is necessary to compensate the input impedance at the grid of the first amplifier stage by adding either capacitance or inductance before beginning any measurements. Even if you have terminated the cable with its characteristic impedance, you cannot expect an exact impedance match because of the valve input impedance with its associated capacitance. In most cases, compensation is not necessary for bandwidths under 2 Mc when the connecting cable to the test item is shorter than 1 metre.

3.1.2 Measuring the Resonance Frequency

In order to measure a resonance frequency, it is in most cases sufficient to fasten the RF diode probe to the chassis at a short distance from the resonant circuit under investigation. It is also possible to couple to the anode of the amplifier valve using a small capacitor with 0.5 to 1 pf. The detuning and damping of the resonant circuit remain so small that you can accurately measure the resonant frequency and bandwidth of the tuned circuit. Only with low-gain amplifier stages and low- Q resonant circuits is it necessary to make a direct connection with the RF diode probe. The resonant frequency of a tuned circuit is determined with the help of the frequency markers.

3.1.3 Measuring the Q of a Tuned Circuit (Bandwidth)

To measure the Q of a tuned circuit, use the following procedure:

- (1) Place the selector switch (19) of the vertical-deflection amplifier in the position "EMF". The trace obtained can now be used as a reference line.
- (2) Increase the fine attenuator control (7) by 3 db so that the height of the displayed resonance curve is reduced by exactly the same amount.
- (3) Place the reference line at the top of the resonance curve with the aid of the vertical gain control "Y₂".
- (4) Return the attenuator to the initial setting.

With the aid of the reference line marking the 3-db level and the frequency markers, determine the lower and upper frequency limits, f_1 and f_2 , which establish the bandwidth.

The Q of the tuned circuit is calculated from the relationship

$$Q = \frac{f_o}{\Delta f}$$

where Δf is the bandwidth ($f_2 - f_1$) and f_o is the resonant frequency.

3.1.4 Possibility of Measuring Errors

With tuned-circuit bandwidths of less than 50 kc, automatic sweeping at the AC supply frequency may be too rapid, and thus cause measuring errors to occur with respect to bandwidth measurements as well as in the determination of the resonant frequency. For further information, please read section 4. and paragraph 9.5.

You must be careful that the test item is not overdriven. When feeding the POLYSKOP output voltage directly to the grid of an amplifier valve, the calibrated output attenuator must be switched to at least -10 db.

3.2 Measurements on Bandpass Filters (coefficient of coupling and bandwidth)

For the measurement and alignment of bandpass filters, the possibility of the simultaneous display of two quantities proves especially useful.

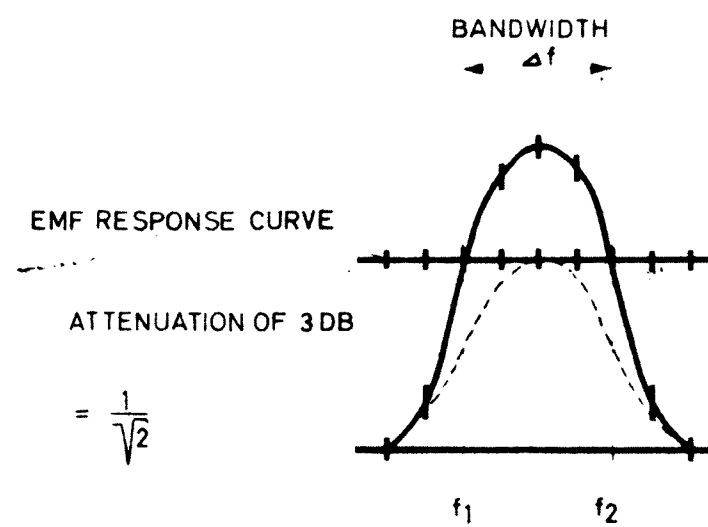
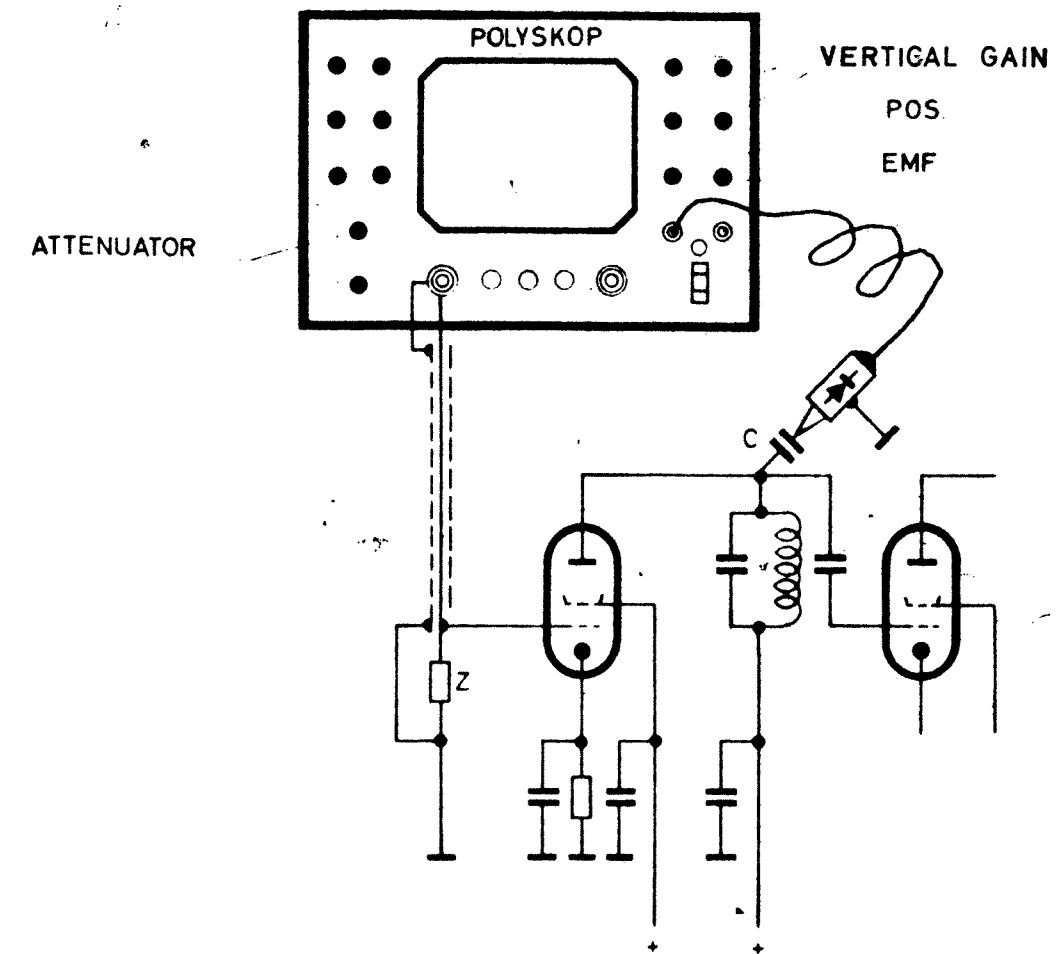


Fig.6 MEASUREMENT OF SINGLE RESONANT CIRCUIT WITH THE POLYSKOP

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3.2.1 Test Setup

The recommended test setup is depicted in the sketch of figure 7. The grid of the first amplifier valve is connected to the POLYSKOP with a cable that is as short as possible. However, the same considerations with regard to impedance matching must be taken into account as was set out in paragraph 3.1 on the measurement of single tuned circuits.

3.2.2 Measuring the Bandwidth

The RF probe is connected to the output of the bandpass filter through a 0.5 to 1 pf capacitor. The amplifier valve of the following stage is left in operation so that its input resistance and capacitance are included in the measurements. The bandwidth is then measured in the same manner as described in paragraph 3.1.3, where the output voltage is lowered 3 db with the calibrated attenuator FINE.

3.2.3 Adjusting the Coefficient of Coupling of a Bandpass Filter

To make this measurement, one RF diode probe is connected to the bandpass filter input in addition to one connected to the output. Both connections are made through small coupling capacitors. The simultaneous display of the two resonance curves is presented on the screen of the picture tube. At critical coupling, the filter input response curve has a saddle depth that is equal to one-half of the saddle maxima at the limit frequencies. The pass-band centre frequency lies at the saddle minimum. In addition, the two saddle maxima should both have the same height if no stray coupling is present inside the amplifier stage.

3.2.4 Possibility of Measuring Errors

Bandpass filters whose amplitude response rises from 10% to 100% within a frequency change of less than 20 kc cannot be measured exactly with the POLYSKOP. For particulars, please read section 4. and paragraph 9.5.

Also you should take care that the test item is not overdriven with an excessive output voltage from the POLYSKOP. An output attenuator setting of at least -10 db is recommended.

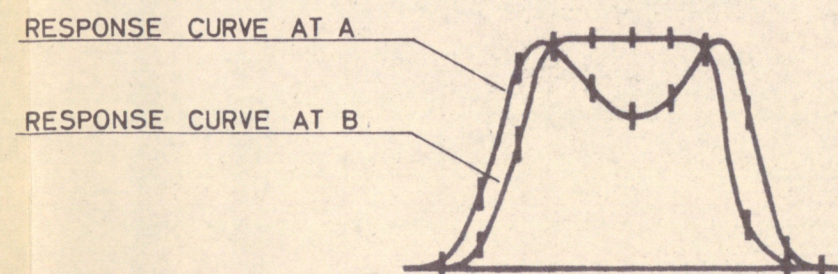
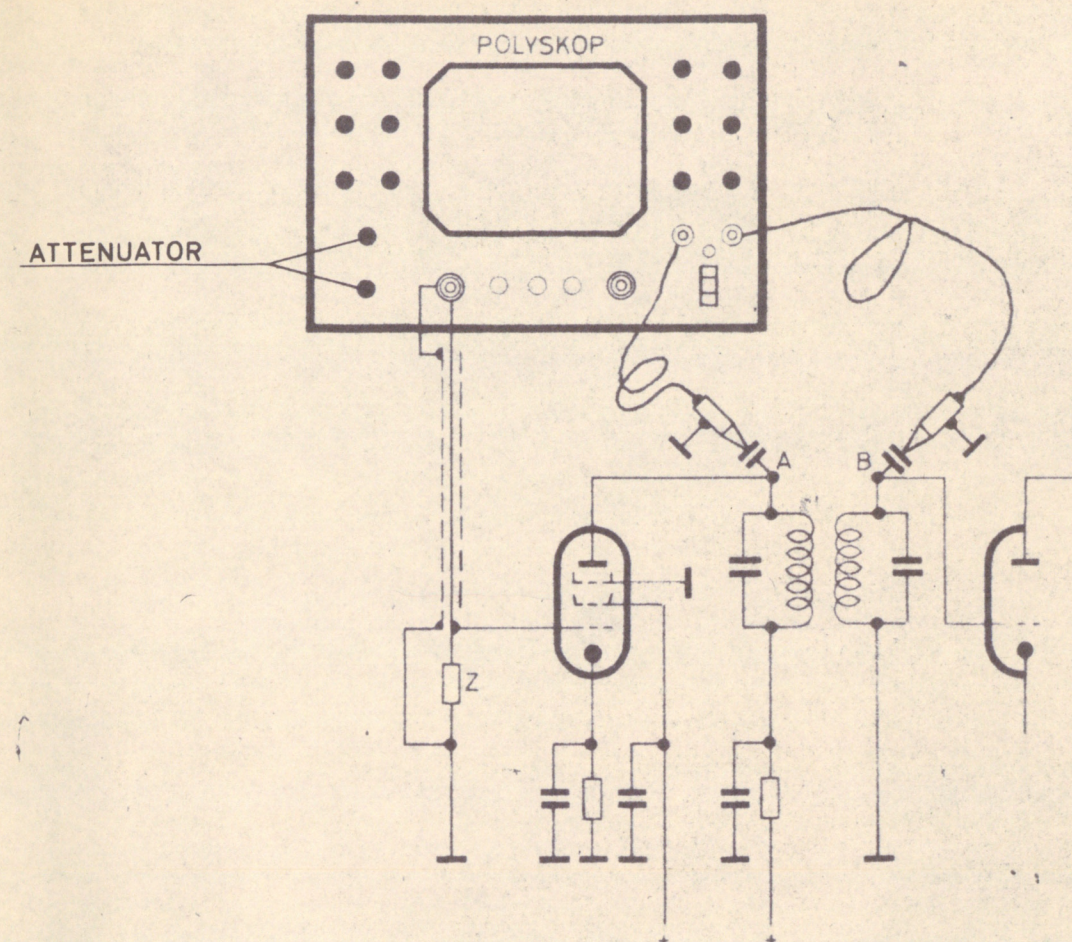


Fig.7 MEASUREMENTS ON BAND D-PASS FILTERS WITH THE POLYSKOP

Bl. 21

3.2.5 Measuring and Aligning Multistage IF Amplifiers

Multistage amplifiers can be aligned and measured with the POLYSKOP in the same manner as already mentioned. However, the possibility of measuring errors increases as the number of IF stages is increased because of the steepness of the amplitude response curve (see section 4. and paragraph 9.5).

3.3 Limiters and Discriminators

3.3.1 Limiters

By coupling one of the RF diode probes with a small capacitor of 0.5 - 1 pf to the anode circuit of a limiter, the output voltage response can be displayed. The range of the limiter action can be recognized by viewing the height of the response curve as the output voltage of the POLYSKOP is varied with the aid of the calibrated attenuator.

The usual limiter draws grid current which builds up a grid bias voltage. This bias voltage can be coupled over a resistance of more than 100 k Ω to the available vertical-deflection amplifier so that both the output response and the grid voltage may be viewed simultaneously. The simultaneous display of these two voltage variables provides an especially clear picture of the limiter action.

3.3.2 Discriminators

Detector arrangements are contained in discriminators so that a discriminator output voltage can be directly coupled through an isolating resistor (over 100 k Ω) to the input of the POLYSKOP. Since the discriminator response curve lies symmetrically about a reference axis, the POLYSKOP 0-reference line is best placed in the centre of the display.

Of special value is the viewing of the response curve of the IF amplifier connected ahead of the first limiter stage simultaneously with the discriminator response curve. Here you can see exactly whether the discriminator is correctly adjusted to the centre frequency of the pass-band. By changing the output voltage of the POLYSKOP, you can check to see if the discriminator response curve remains unchanged throughout the required input level range.

With this measurement, the proper functioning of all the limiter stages is also included.

3.3.3 Possibility of Measuring Errors

The signal-generator output voltage of the POLYSKOP is cut off during the oscillograph flyback period. Because of the high amplification of an IF amplifier with limiter and discriminator, the absence of an input voltage while the signal generator is cut off allows a high noise level to be applied to the discriminator. This is the cause of fluttering in the discriminator display curve. However, this fluttering can cause no distortion of the measured results.

Narrow-band IF amplifiers having a pass-band of less than 100 kc are subject to measuring errors caused from the automatic sweep frequency being too high (AC supply frequency). Please refer to paragraph 9.5 for a detailed explanation.

If measurements are made on amplifier stages whose average current varies with the amount of input drive, the amplitude response may be distorted by a sag in the top of the curve. This is especially true of limiter amplifier stages. In general, the filtering and by-passing capacitors of the anode, screen-grid, and cathode circuits are so dimensioned that they present a sufficient short-circuit in the frequency range of the set. Since the sweep of the POLYSKOP occurs at the AC supply frequency, the filtering and by-passing is not sufficient in many cases to prevent variations in the operating voltages. The amplification of each stage then varies at the AC supply frequency, making it impossible to avoid measuring errors.

In general, the following principles should be observed:

Amplifier stages which do not operate class A (the anode current is a function of grid drive) must have filter or by-pass circuits with time constants greater than 10^{-1} or less than 10^{-4} ; in the first case the filtering is sufficiently large compared with the AC power frequency, in the other case the filtering is sufficiently small so that the amplifier gain does not noticeably change during the sweep time. If the time constants do not meet this requirement, parallel capacitors must be added before making any measurements.

Naturally, such steps are unnecessary for measurements on test items which have anode current conditions that are independent of grid drive (class A). It is only possible to make measuring errors by overdriving an amplifier stage, which upsets its pure class A operation.

3.4 Filter Alignment

Any passive element such as a low-pass, high-pass, or bandpass filter may be measured and aligned with the POLYSKOP. In addition to viewing the output response, you can view the degree of filter mismatch to a cable of known characteristic impedance Z_0 by observing the height of the E_{out} wave pattern.

3.4.1 Connecting the Test Item

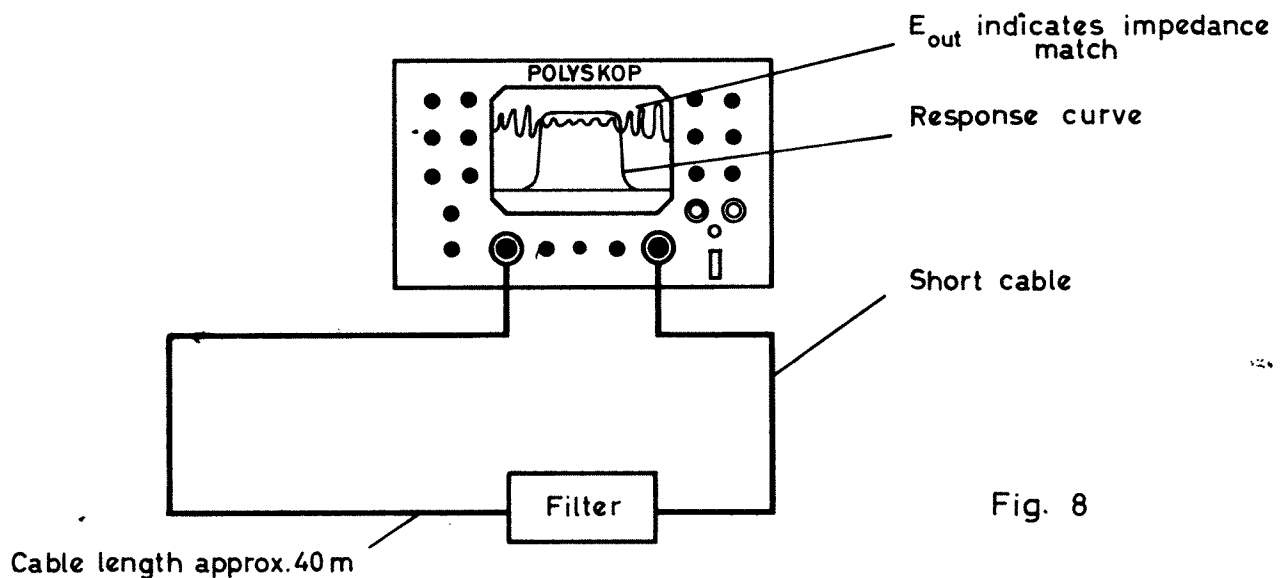


Fig. 8

Connect the test item to the POLYSKOP RF input and RF output as shown in the above diagram (Fig. 8). In order to view the wave pattern of E_{out} caused by mismatching, you must connect to the input of the test object a high-quality cable that is at least 30 metres in length. Cables suitable for the POLYSKOP can be delivered upon request and are available with various characteristic impedances. For details, please refer to the compilation of data and accessories under paragraph 6.6.

3.4.2 Measurements

By observing the test item's response characteristic as well as its impedance match response, compensation problems can be solved in a very short time. Please refer to paragraph 3.12.6.

3.4.3 Interpretation of the Measurement Results

Exact information on the measurement of input standing-wave ratios along with the obtainable measuring accuracies is given in paragraph 3.12, "Cable Measurements".

3.4.4 Filter Adjustment Against a Standard

The dual display feature of the POLYSKOP is especially suitable for adjusting test items against a calibrated standard for use in quantity production.

The calibrated standard and the test item are both connected to the RF OUTPUT of the POLYSKOP using a T-connector with $3 \times Z_0/3$. If a long high-quality cable is used for the connection between the POLYSKOP and the T-connector, the input impedance of the test item can be compensated for with a reasonably high accuracy. The adjustment of the test item is accomplished when the two displayed response curves sufficiently cover one another. By switching one of the two vertical-deflection amplifiers to the position E_{out} , the input-impedance match of the test item can be displayed.

3.4.5 Possibility of Measuring Errors

Extremely steep filter response curves cannot be exactly resolved with the POLYSKOP. Only the steepness of the response curve is important and not the bandwidth. For example, a low-pass filter with an extremely sharp cut-off at 10 Mc cannot be measured with a frequency sweep of 10 Mc. However, it is possible under certain circumstances to investigate the cut-off region separately when it is not steeper than 20 kc for an amplitude drop from 100% to 10%. This measurement is made by decreasing the sweep width. Please refer to section 4. and paragraph 9.5.

3.5 Measuring the Gain of an Amplifier Stage

To measure the gain of an amplifier stage, the following procedure is recommended:

- (1) Connect the RF OUTPUT of the POLYSKOP to the input of the amplifier under test.
- (2) Connect one of the RF diode probes to the anode of the amplifier valve.
- (3) Turn the vertical-deflection amplifier gain to maximum with control "Y₁" or "Y₂".
- (4) With the aid of the OUTPUT ATTENUATOR control, increase the attenuation until the response curve lies at the top of the display screen.
- (5) Connect the RF probe to the amplifier input and decrease the attenuation with the OUTPUT ATTENUATOR control until the response curve lies at the same place as under step 4.

The difference in the db readings of the OUTPUT ATTENUATOR control is the db gain of the amplifier stage under test. With the two built-in calibrated attenuators, it is possible to obtain a high degree of accuracy from a measurement of this kind.

3.6 Video and Distributed Amplifiers

For measurements on video amplifiers, the lowest frequency range of 0.5 to 50 Mc is especially suitable because of the large adjustable sweep width. Not only can you measure the frequency response range for which the amplifier is designed, but also the higher frequencies where resonant peaks may occur. In general, these resonant peaks can be attributed to unsuitable coupling capacitors or poor filtering and often give rise to unexplainable overshoots when observing transients.

Of special importance when making measurements on distributed amplifiers is the fact that the RF output voltage of the POLYSKOP remains at the same value when the frequency range switch is switched from position to position. It is possible to investigate the response curve of a distributed amplifier from 0.5 to 400 Mc in five frequency ranges.

3.6.1 Possibility of Measuring Errors

Video and distributed amplifiers appear as active four-terminal networks with low-pass characteristics. Since they contain non-linear elements in the form of amplifier valves, a distortion of the amplified frequencies may occur through overdriving or incorrect design. The effect of distortion, which exists up to 5% in the signal generator output but may in addition be caused by the test item, is described in detail under paragraph 9.6.

3.7 Determining the Frequency of a Signal Source

3.7.1 Method of Measurement

The frequency markers of the POLYSKOP are produced through the interference of the POLYSKOP signal generator frequency with the spectral lines produced by the marker frequency generator. If the output frequency of a signal generator or oscillator is connected to the RF OUTPUT of the POLYSKOP, a beat frequency marker is produced whose position may be compared with one of the markers produced by the POLYSKOP signal generator. In this manner it is possible to check the calibration of signal generators or oscillators after, for example, a valve has been replaced. The accuracy corresponds to the accuracy of the crystal marker generator in the POLYSKOP and is not very high ($\pm 1 \times 10^{-4}$), but sufficient for many purposes.

3.7.2 Test Setup

If the output voltage of the signal source is about 1 v_{rms} , it may be applied to the EXTERNAL MARKER input at the rear of the POLYSKOP and displayed in the manner usual for external frequency markers. When the FREQUENCY MARKERS control is placed in the "1 MC" or "10 MC" position, the internal frequency markers become visible and may be compared with the position of the appearing external marker. By slowly adjusting the frequency of the signal source, the coincidence of one of the internal spectral lines with the signal-source frequency is manifested by a very low beat frequency pattern that is visible across the entire screen.

When the signal source to be tested delivers a small output voltage, it must be connected to the RF OUTPUT of the POLYSKOP. With the OUTPUT ATTENUATOR

placed in the "-20 DB" position and one of the vertical-deflection amplifiers placed in the "E_{OUT}" position, the RF output voltage of the POLYSKOP is measured. The frequency determination is made by comparison in the same manner as described above.

To align the local oscillator of a receiver through any desired tuning range, the frequency sweep width is so adjusted that the total range in which the oscillator is to function is displayed across the screen. The beat frequency pattern produced by the oscillator wanders across the screen as the oscillator is tuned through its tuning range.

3.8 Checking the Frequency Calibration on Receivers

The frequency spectrum from 1 to 400 Mc can be brought out at the rear of the POLYSKOP to be used in checking the calibration of receivers in this frequency range.

With the FREQUENCY MARKER selector switch in the position "1MC", the output voltage varies with frequency as follows:

30 Mc	3	mv
100 Mc	2	mv
200 Mc	0.8	mv
300 Mc	0.2	mv
400 Mc	0.1	mv

With the FREQUENCY MARKER selector switch in the position "10 MC", the output voltage is:

30 Mc	30	mv
100 Mc	3	mv
200 Mc	2	mv
300 Mc	1	mv
400 Mc	0.5	mv

This specification represents only approximate values and may vary from set to set.

Measured at 20°C ambient temperature, the accuracy of the POLYSKOP marker generator is $\pm 1 \times 10^{-4}$ with a temperature coefficient of $1 \times 10^{-6}/^{\circ}\text{C}$. This limits the realizable accuracy.

3.9 Alignment of Television Receiver Components

The following measurements may be carried out for checking and aligning television receivers:

- (a) Alignment of RF tuners in all channels of Bands I and III.
- (b) Alignment of IF amplifiers (video IF amplifiers)
- (c) Alignment of the intercarrier sound sections (IF section, limiter, discriminator).
- (d) Alignment of video amplifiers up to the picture-tube connection.
- (e) Overall check from the VHF input to the picture-tube connection with the simultaneous observation of the video response and discriminator characteristic curve.

3.10 Measurements on Multicouplers

The possibility of covering a wide band of frequencies with a single test instrument is especially advantageous in the development and production of multicouplers for use in community antenna systems. Measurements on these units for use in the broadcast, shortwave, FM and television bands can be carried out in a very short time.

3.11 Locating Bad Earthing Conditions

Because of their high sensitivity the RF diode probes of the POLYSKOP are well suited for investigating bad earthing conditions.

3.11.1 Test Setup

Connect the test item to the POLYSKOP as for measuring the amplitude response. Adjust the centre frequency and sweep width until the entire frequency range of the test item is covered.

The RF diode probe may be used to make checks on the test item to determine the adequacy of RF filtering, i.e. that no unwanted RF voltages are present which may lead to instability. When making alignments, inadequate filtering in multistage RF or IF amplifiers causes difficulty in that the calculated

passband is not attained and the individual stages may have too much gain which may lead to instable conditions.

The same symptoms may appear from a bad choice of earthing points. In some instances, an earth conductor only a few centimetres in length may cause RF voltage drops in the order of several millivolts. If the return paths of several circuits are run via the same earth conductor, common earth pick-up may cause malfunctioning of the circuits. By measuring the voltage drop between the suspected earth points, such errors are rapidly found.

3.11.2 Possibility of Measuring Errors

In all measurements made with the RF diode probe, it is imperative that a good connection be made between the shell of the diode probe and the earth of the test item. This is a prerequisite for the accurate measurement of the RF voltage appearing between the electrode of the RF probe and earth.

3.12 Measurements on Cables, Cable Connectors and Termination Impedances

To aid in the understanding of the following paragraphs on measuring techniques, a review of fundamental concepts will first be given.

If we measure the input impedance of an open-ended high-frequency cable as a function of frequency, we observe that at very definite frequencies the impedance becomes almost infinite. As a function of frequency, we obtain the following picture (Fig. 9).

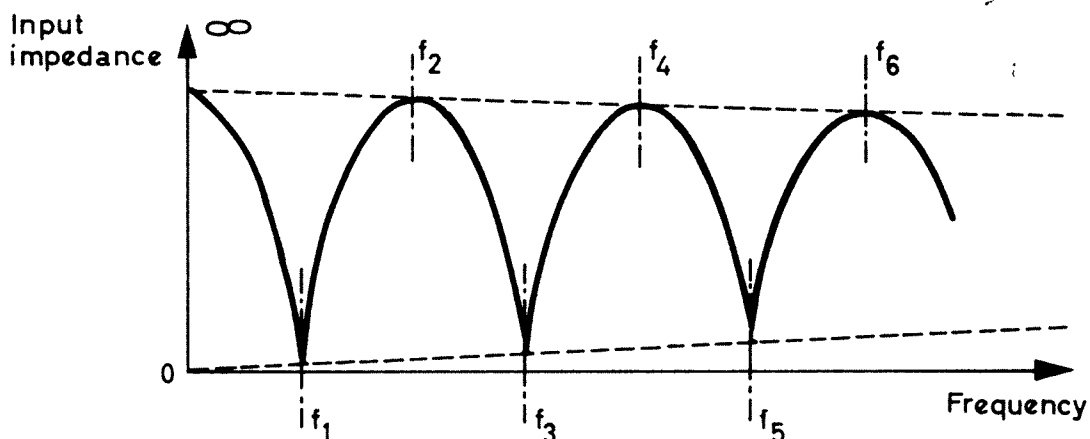


Fig. 9

At zero frequency (DC), the input impedance is almost infinite. The finite value of the impedance is caused only by the insulation resistance between the inner and outer conductors. With increasing frequency, the input impedance decreases and reaches a minimum at f_1 . Because of the dielectric losses, the minimum impedance does not reach zero. As the frequency is further increased, a second maximum is reached at f_2 , where f_2 is twice the value of f_1 . At every integral multiple of f_1 , we measure maxima and minima of the input impedance. We observe that the maxima and minima no longer reach the same values that they had at the lower frequencies. This is due to the fact that the dielectric losses are dependent on frequency and become greater as the frequency is increased.

Repeating the same measurement, but with the cable short-circuited, we measure a very low resistance at zero frequency which is primarily the DC resistance of the inner conductor. At the frequency f_1 , a maximum is obtained where a minimum was for the open-ended cable. Maxima and minima are merely interchanged at the same frequency intervals.

At what frequency f_1 we find the first minimum in the case of the open-ended cable depends upon its electrical length. The electrical length of the cable may be calculated from its mechanical length, taking into account the dielectric constant of the material between the inner and outer conductors. By determining the frequency f_1 or, for example, the difference between f_8 and f_9 , we may calculate the dielectric constant when the mechanical length is known or vice versa.

If we terminate the cable with its characteristic impedance Z_0 , we measure always the same input impedance Z_1 . In practice, the impedance Z_1 deviates a small amount above and below the Z_0 value. To measure a constant Z_1 value, the cable must have the exact same distance between the inner and outer conductors throughout the entire length. In addition, the electrical properties of the insulation material must be also exactly the same throughout the cable length.

The response of the input impedance as a function of frequency is a measure of the cable quality, i.e. the homogeneity of its electrical and mechanical properties.

If we terminate such a cable with a resistor that varies from Z_0 as a function of frequency, a wave pattern is displayed which indicates the amount

of mismatch. By such measurements, we may recognize the degree of mismatch and then make compensations until the displayed waves are brought to a minimum.

3.12.1 Measuring Technique and Test Setup

A diode is built into the RF output socket of the POLYSKOP so that measurements on cables may be carried out with ease. The diode measures the output voltage response E_{out} which is then displayed directly on the screen of the picture tube. The wide frequency range from 500 kc up to 400 Mc makes it possible to carry out measurements on cables as short as 1 metre in length. To make a measurement, the cable to be tested is connected to the RF OUTPUT of the POLYSKOP. The OUTPUT ATTENUATOR is placed in the "-10 DB" position to prevent heavy mismatch (more than 30%) of the cable characteristic impedance to that of the POLYSKOP from reacting on the EMF control circuit. The output voltage E_{out} is then displayed as a function of frequency.

3.12.2 Determination of the Characteristic Impedance Z_o

Connect several metres of the cable to be tested to the RF OUTPUT of the POLYSKOP. Adjust the sweep width to cover the frequency range of the cable. As long as the cable is left open-ended, the maxima and minima of the wave pattern appear as described in the foregoing. Terminate the cable with various pre-determined resistance values until one is found that produces a minimum wave pattern. It is important that the terminating resistor be connected as closely as possible to the end of the cable between the inner and outer conductors. This is especially important when measuring at very high frequencies. The terminating resistance found in this manner is equal to the characteristic impedance Z_o of the cable. The Z_o value may be measured within an accuracy of 1% if a compensated, variable terminating resistor is used.

The source impedance of the POLYSKOP is of subordinate importance in this measuring technique. However, the obtainable accuracy does increase, the lower the Z_0 value of the cable to be tested or the higher the source impedance of the POLYSKOP. The best arrangement to obtain the highest accuracy would be to feed the cable under test from a constant current source and not from one with a constant EMF and a finite source impedance.

3.12.3 Determining the Dielectric Constant

To determine the dielectric constant, several metres of the test cable are connected to the POLYSKOP, the free end being left open-ended. Beginning with the lowest frequency range of the POLYSKOP, 0.5 to 50 Mc, we determine the first voltage minimum E_{out} in the wave pattern which represents the first impedance minimum. For the exact measurement of the frequency f_1 , it is recommended that a well calibrated signal generator be connected to the external marker input and the resulting frequency markers be used to measure the frequency at the minimum impedance point. The sweep width should be reduced far enough so that the minimum impedance point may be easily and accurately measured.

From the measured frequency f_1 and the mechanical length of the cable, the dielectric constant ϵ may be calculated from the relationship

$$\epsilon = \left(\frac{c}{4 f_1 l} \right)^2$$

c = speed of light in metres/sec (3×10^8)

l = mechanical length of the cable in metres

3.12.4 Determining Cable Attenuation

The attenuation of a cable is a function of frequency, increasing as the frequency increases. The attenuation, measured at a definite frequency or in the frequency range 0.5 to 400 Mc, is easily determined from the POLYSKOP display. To make this measurement it is advisable to use a cable longer than 10 metres connected between the RF OUTPUT and the RF INPUT of the POLYSKOP.

The measurement is performed as follows:

- (1) Connect the 1-metre precision cable between the RF OUTPUT and RF INPUT.
- (2) Set the OUTPUT ATTENUATOR in the "-20 DB" position and the vertical-deflection amplifier selector switch to the position "RF".
- (3) With the VERTICAL GAIN control "Y₁", adjust the displayed trace to line 10 on the graticule.
- (4) Replace the 1-metre precision cable with the cable to be tested.
- (5) Switch back the OUTPUT ATTENUATOR control until the displayed trace is again at line 10.

The difference in the OUTPUT ATTENUATOR settings is equal to the cable attenuation at the adjusted frequency or, as the case may be, at the adjusted frequency range. Since the calibrated attenuator can be adjusted in 1-db steps, a high measuring accuracy can be obtained.

In modern cables completely filled with dielectric material, the mechanical length is shorter than the electrical length by a factor k as calculated from the relative dielectric constant (see para. 3.12.3).

$$k = \frac{1}{\sqrt{\epsilon}}$$

ϵ = relative dielectric constant

3.12.5 Determining the Homogeneity

For example in the production of cables, it is possible to check the homogeneity of a cable if a piece of cable as long as possible is connected to the RF OUTPUT of the POLYSKOP and terminated with its characteristic impedance using a precision terminating resistor. Cables that are not homogeneous produce standing waves which manifest themselves as input impedance varia-

tions. The first impedance minimum or maximum at the lowest frequency f_1 permits the point of reflection or discontinuity to be rapidly located.

3.12.6 Measuring with a Mismatched Cable (Matching, Reflection Coefficient)

The POLYSKOP is suitable for the following measurements in conjunction with a long high-quality reference cable available as an accessory with characteristic impedances of 50, 60, or 75 Ω , respectively.

- (a) Measuring the input impedance of filters, amplifiers, receivers, etc. and compensating for mismatch.
- (b) Measuring the reflection coefficient
- (c) Testing of cable connections
- (d) Antenna matching measurements

(The characteristic impedance Z_0 of the reference cable does not necessarily have to be equal to the source impedance of the POLYSKOP. See para. 3.12.2).

If a high quality cable is connected to the output voltage of the POLYSKOP and terminated with its characteristic impedance, the output voltage E_{out} shows very small variations throughout the frequency sweep. If the cable is terminated with the input impedance of a test item, the voltage E_{out} varies with frequency, indicating the degree of mismatch. In the frequency range with the best matching, the E_{out} variations are at a minimum. Outside of the range of compensation, the E_{out} variations, thereafter referred to as E_{out} undulations, increase (Fig. 10).

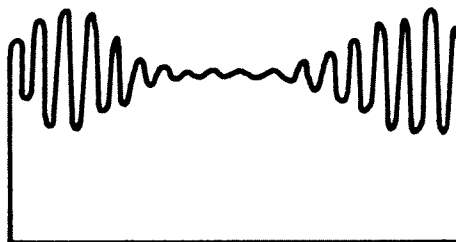


Fig. 10

The magnitude of the voltage undulations of E_{out} is a direct measure of the degree of mismatch or the resulting reflection coefficient.

The simplest method for calculating the reflection coefficient is by measuring the amplitude of the E_{out} voltage undulations at the cable input when the cable is open-ended and when connected to the test item.

The amplitude of the undulations with the cable open-ended be A_1 , the amplitude with the test item connected, A_2 . The reflection coefficient is then

$$r = \frac{A_2}{A_1}$$

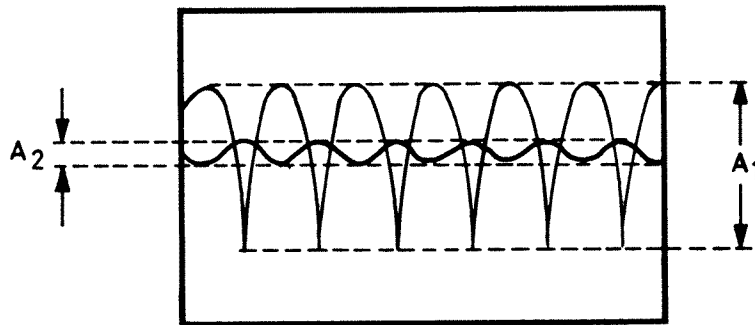


Fig. 11

(When making these measurements, the OUTPUT ATTENUATOR must be switched to the "-10 DB" position).

These measurements have the advantage that the attenuation of the reference cable has no effect on the measuring accuracy. The disadvantage lies in the fact that, due to the non-linearity of the built-in diode rectifier of the POLYSKOP, the amplitude relationship measured is too high, i.e. the calculated reflection coefficient is too small.

A higher measuring accuracy may be obtained in the following manner:

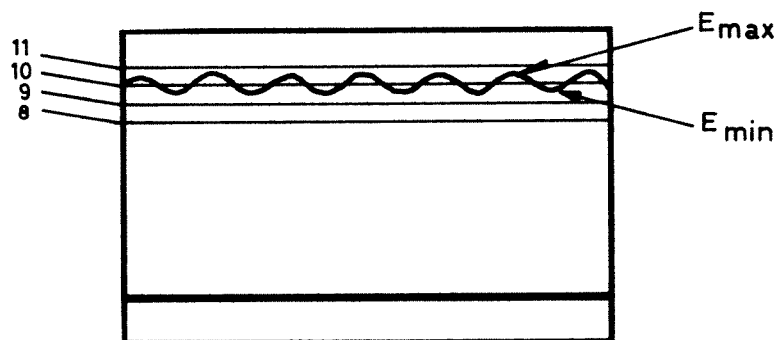


Fig. 12

The maximum and minimum voltages $E_{\max}$ and $E_{\min}$ displayed on the POLYSKOP represent the transformation of the terminating resistance to the input of the cable. Either $E_{\max}$ or $E_{\min}$ may be used to calculate the mismatch or the reflection coefficient. The cable maximum and minimum input impedances $Z_{\max}$ and $Z_{\min}$, which are purely resistive, are calculated from the fact that the signal generator EMF E_o is divided between the generator source resistance R_i and the cable input impedance in a simple ohmic relationship.

The resulting equations are

$$Z_{\max} = R_i \frac{E_{\max}}{E_o - E_{\max}} \quad \text{or} \quad Z_{\min} = R_i \frac{E_{\min}}{E_o - E_{\min}} \quad (\Omega)$$

From the value of $Z_{\max}$ or $Z_{\min}$, the reflection coefficient r may be calculated.

$$r_2 = \left| \frac{Z - R_i}{Z + R_i} \right| \quad Z = Z_{\max} \text{ or } Z_{\min}$$

For fast measurements with the POLYSKOP, the above equations are changed into another form as follows:

We adjust the POLYSKOP so that the undulations of the E_{out} curve lie symmetrical to the line 10 on the POLYSKOP graticule. From the maximum value of the indicated voltage $E_{\max}$ or the minimum value $E_{\min}$, we are able to calculate $Z_{\max}$ and $Z_{\min}$. The value of the signal generator EMF (E_o) is important for the calculation. The scale value may be taken as 20 for the case where the cable impedance Z_o matches the POLYSKOP source resistance R_i . Since this is not always the case because we want to measure different types of cables, a tabulation is given of the E_o scale values for each impedance combination between the POLYSKOP and the reference cable.

		Source Impedance of POLYSKOP (Ω)		
		50	60	75
Cable Z_o (Ω)	50	20	22	25
	60	18.3	20	22.5
	75	16.7	18	20
	150	13.3	14	15
		E_o Scale Value		

For other cables, the following formula may be used to calculate the E_o scale value:

$$E_o = \frac{10 (R_i + Z_o)}{Z_o}$$

From the measured value of $E_{\max}$ obtained from the POLYSKOP graticule, say 10.7, we calculate $Z_{\max}$

$$Z_{\max} = \frac{E_{\max}}{E_o - E_{\max}} R_i \quad \text{e.g.} \quad Z_{\max} = \frac{10.7}{20 - 10.7} 60 = 69 \Omega$$

In the same manner, we may calculate $Z_{\min}$. From the value of $Z_{\max}$ we may calculate the reflection coefficient r .

$$r = \frac{Z_{\max} - Z_o}{Z_{\max} + Z_o} \quad \text{e.g.} \quad r = \frac{69 - 60}{69 + 60} = 0.07 = 7\%$$

The above calculations give results as long as the reflection coefficient lies under 20% and the reference cable attenuation at the frequency of measurement may still be neglected.

For example, if we measure 40 metres of precision cable at 200 Mc, we must take into account that the RF voltage reflected from the end of the cable reaches the cable input at a lower value because of the cable attenuation. For instance, in the example of paragraph 3.12.4 where the cable attenuation was found to be 3 db at 200 Mc, the E_{out} undulations produced by the reflected voltage would be reduced by $2 \times 3 = 6$ db, or to one-half of the value obtained from a cable with no attenuation. In the above numerical example, the displayed undulations would vary twice as far from the reference line 10, i.e. from 10.7 to 11.4, if the cable under test had no attenuation.

$$Z_{\max} \text{ then equals } \frac{11.4}{20 - 11.4} 60 = 80 \Omega$$

$$\text{so that } r_2 = \frac{80 - 60}{80 + 60} = 0.14 = 14\%$$

Here we see that the true reflection coefficient of a cable with $2 \times 3 = 6$ db attenuation actually is greater by a factor of 2.

3.12.7 Determining the Phase Angle of the Reflection Coefficient

The phase angle φ of the reflection coefficient can be determined with fairly good accuracy. To make this measurement, the cable is first driven open-ended. The frequency difference of two minima f_1 is measured. The test item is then connected and the entire curve of maxima and minima is displaced. The frequency displacement of the same minimum point is designated as f_2 . From the two values f_1 and f_2 , we may calculate the phase angle of the reflection coefficient.

$$\varphi = 2\pi \frac{f_2}{f_1}$$

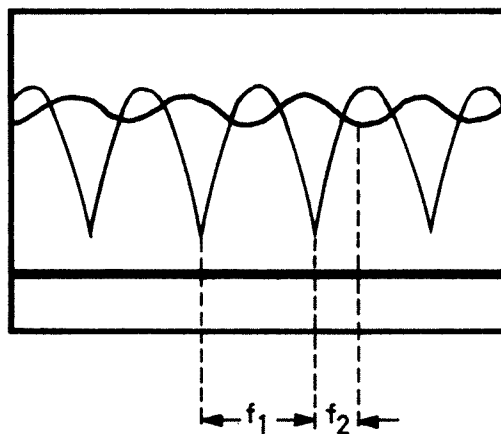
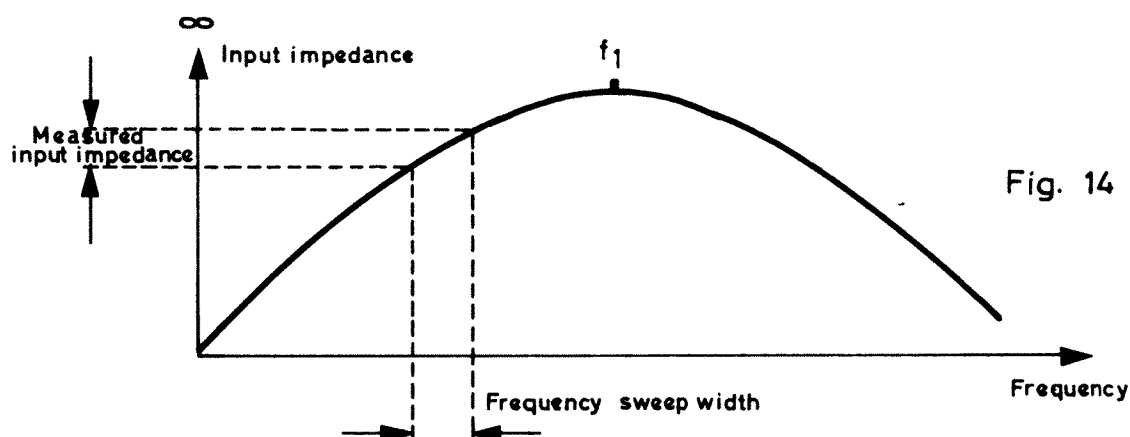


Fig. 13

To obtain a more accurate measurement of the frequency, a well calibrated signal generator is used. The frequency sweep is decreased far enough to allow a good measurement of the minima to be made with sufficient accuracy.

3.12.8 Possibilities of Measuring Errors

A measurement of the input impedance of a test item is only possible when the test item is connected to a cable of sufficient length. At least two maxima or minima must appear in the display. If this is not the case, it is obvious that no definite value of input impedance could be measured that had any relationship to the actual value.



Let us suppose, for example, that a test item is connected to the POLYSKOP with a cable of 1 metre in length. With the cable short-circuited, the first maximum appears at about 50 Mc. Depending upon the frequency at which we measure, the input impedance varies between zero and infinity (Fig. 14). Measurement may begin only after at least two maxima and minima are displayed, whereas the accuracy becomes greater the more minima and maxima are displayed in the frequency range in which we are interested.

A mismatch of around 30% may react upon the EMF control circuit of the POLYSKOP and cause a measuring error. Always check the EMF in this case to see that the control circuit is not being influenced. When the OUTPUT ATTENUATOR is in a position greater than "-10 DB", there is no influence upon the EMF control circuit even with mismatches up to 100%.

Low level input stages can be easily overdriven with an excessive input voltage which gives the same indication as a heavy mismatch. For this type of measurement, it is advisable to set the OUTPUT ATTENUATOR in the position "-20 DB". In this case, 50 mv_{rms} are applied to the test item, thus causing no danger of overdriving.

4. How to Avoid Measuring Errors

The possibilities of measuring errors have been pointed out in connection with various application examples. The important points are brought together once again to form a compilation of rules to be observed when using the POLYSKOP.

4.1 Measuring Errors Caused by Using an Excessive Sweep Width

Inherent in the automatic frequency sweep of the POLYSKOP is the relatively short time that the measuring frequency dwells in the pass-band of the test item. When measuring test items with very small bandwidths or when the frequency sweep width is quite large, the dwell time is so short that the test object cannot give its full amplitude response. In this case the bandwidth as well as the resonant frequency of the test item is not correctly measured. The simplest test to see if the test item is responding with full amplitude is to reduce the sweep width. If no change is observed in the height of the amplitude display or in the position of the resonant frequency on the frequency scale, you may be certain that there is no measuring error. For details on the problem of resolving high Q resonant circuits and sharp cut-off filter responses, please read under section 9., and particularly paragraph 9.5.

4.2 Overdriving the Test Item

Always make certain that the POLYSKOP output voltage does not exceed the maximum permissible input voltage of the test item. By overdriving, the frequency response is distorted and measuring errors are possible.

4.3 Measuring Errors Caused by Distortion

The response of video amplifiers, low-pass filters and low Q band-pass filters can be measured with an accuracy that is limited by the distortion created in the POLYSKOP. The measuring errors produced may be held small when the measured voltage applied to the RF diode probe or RF INPUT is as high as possible with peak responsive rectification still being assured. Steps up to 10% in the frequency response at one-half of the limit frequency of the test item can be caused by the inherent distortion of about 5%. Distortion may be caused to even a greater extent by the test item itself when dealing with a c t i v e four-terminal networks.

4.4 Hum and RF Pickup

You must always be careful that a good earth connection is made between the test item and the shell of the diode probe. At the higher frequencies, under no circumstance use a thin, long conductor for earth connections. No changes in indication should be permitted when the diode probe is moved about. Also in other measurements, no fluctuations in indication should be tolerated when the test setup instruments and cables are moved. Often, it is necessary to free all pieces of equipment in the test setup from earth connections except the POLYSKOP. Especially sensitive in this respect are test items with high amplification and undefined RF earth conditions.

If the test item already contains a rectifier circuit, whose output is to be measured on the POLYSKOP, measuring errors may be caused by hum pickup. This hum synchronized with the AC supply frequency is recognized by a shifting of the displayed response curve as the centre frequency is varied. A distortion in the form of the displayed curve is a sure indication of hum pickup.

4.5 Measuring Errors Caused by Overdriving the Vertical Deflection Amplifier

Care should be taken that the displayed curve projects at no point above the upper limit of the picture-tube screen since indication errors are caused by overdriving the vertical-deflection amplifier. If the right side of the display is moved below the 0-reference line when the Y-deflection amplifier gain is increased (control (20) or (21), Fig. 5), this is a sure indication of overdriving. When using dual display, the overdriving of one amplifier disturbs the indication of the other amplifier.

When switching the selector (18) or (19), for example, from a position for diode probe measurements to the position "EMF" where a large change in amplitude takes place, the Y-deflection amplifier can be so overdriven that it takes a few seconds before the amplifier valves re-establish their operating points. In such cases it is advisable to turn the appropriate gain control back to zero, wait a few seconds and then slowly increase the gain to the desired value.

4.6 Measuring Errors Caused by Oscillator Pickup

If the output of the POLYSKOP is fed into the mixer stage of a receiver, it is possible that the receiver oscillator voltage may be coupled into the POLYSKOP output circuit and affect the EMP control circuit or the E_{out} response indications. The effect on the EMP control circuit is reduced by switching in more attenuation. It is very difficult to prevent the E_{out} response from being affected in such cases; the other circuits of the POLYSKOP are not influenced.

4.7 The POLYSKOP is not Suitable for the Following Measurements

- (a) Measurements on test items whose amplitude rises from 10% to 100% within less than 50 kc; for example, crystal filters or multistage narrow-band IF amplifiers.
- (b) Measurements with sweep widths less than 400 kc.
- (c) The POLYSKOP is no spectrum analyzer. It cannot be used as a selective amplifier to measure the spectral energy distribution in definite bands without special accessories.
- (d) The POLYSKOP is no frequency measuring device of the highest accuracy. For particulars on the obtainable accuracy in frequency measurements, please read paragraph 3.8.
- (e) The POLYSKOP is no impedance measuring device in the exact sense of the word. For determining impedances with respect to absolute value and phase, the ROHDE & SCHWARZ Z-g Diagram Type ZDU is recommended. To make impedance matching measurements of limited accuracy with the POLYSKOP, please read paragraph 3.12.
- (f) No stable frequency can be taken from the POLYSKOP. Even when the sweep-width control is completely turned back, a frequency sweep of approx. 50 kc still remains, plus a slow frequency drift caused by fluctuations in the operating voltages.

INDEX to the Circuit Description of the POLYSKOP

	Page
5.1 <u>Signal Generator Section</u>	46
Sweep oscillators	46
Mech. coupling of sweep and centre frequency control . . .	48
Sweep linearization oscillators	48
Band 0.5 to 50 Mc	48
Output attenuator	49
E _{out} indication	49
RF control circuit	49
Amplifier for AC variations	51
EMF indication	51
Signal generator source resistance	51
Frequency sweep	52
Horizontal beam deflection	52
Keying off	52
Generation of keying voltage	52
Amplitude modulation of the RF signal	52
5.2 <u>Display Section</u>	53
RF input	53
Vertical deflection amplifier inputs	53
Vertical deflection amplifiers	53
Selectable polarity	54
Electronic switching	54
Clamping circuit	54
Negative deflection current	55
Clamping circuit	55
DC amplifier	56
Electronic switching	56
Generation of the switchover pulses	57
Electronic switching	57

	Page
5.3 <u>The Marker Generator</u>	58
Generation of the fundamental frequencies	58
Harmonic generation	58
Marker mixing	58
Marker amplification	58
 5.4 <u>Power Supply</u>	 59
Heating	59
RF generator heating	59
Stabilized heater circuit	59
Anode supply voltage	59
HT voltage	60
High voltage	60
Negative voltage	60
Blower	60

5. Circuit Descriptions

The POLYSKOP Type SWOB is a wide-sweep signal generator containing a dual-display oscilloscope. The sweep of the signal generator and the horizontal deflection of the oscilloscope occur at the same alternating current rate. They are connected to the AC supply frequency which establishes the fixed phase relationship. The frequency-dependent quantity under test, mostly the amplitude response, is used to drive a vertical deflection amplifier.

The POLYSKOP mainly consists of four sections:

- (1) Signal generator section
- (2) Vertical deflection amplifiers with picture tube
- (3) Marker generator
- (4) Power supply

5.1 Signal Generator Section

The signal generator section of the POLYSKOP contains five frequency ranges:

0.5	to	50 Mc
50	to	150 Mc
150	to	220 Mc
220	to	310 Mc
310	to	400 Mc

Sweep
oscillators

The RF voltages are produced in single-stage oscillators except in the 0.5 to 50 Mc band. Each frequency range is covered by a separate oscillator (Rö8 and Rö9). Band switching is brought about by applying the anode supply voltage to the appropriate oscillator valve and feeding its RF voltage to the output of the set via a relay (RLS 1, 2, 3 and 8). The oscillators function in a Colpitts circuit using the valve anode-grid capacitance. The tank circuit inductance contains a small ferrite-rod core placed between the pole shoes of an AC electromagnet. The ferrite-rod core is magnetized since it lies in the path of flux produced by the "driver coil" of the electromagnet. The permeability of the ferrite core is thereby changed causing the frequency of the oscillator to be changed. Depending upon the frequency range, the frequency can be varied up to 100 Mc in this manner.

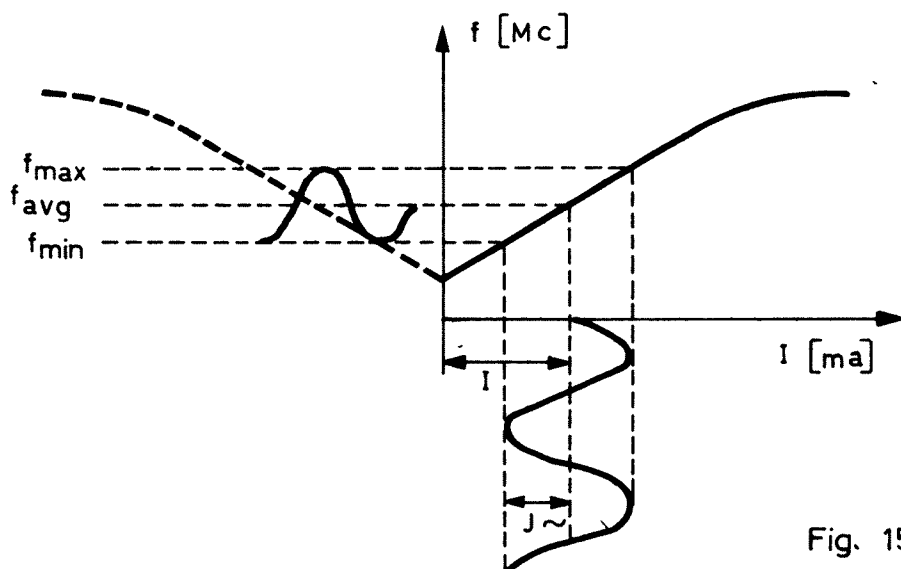


Fig. 15

As can be seen in Fig. 15, the relationship between the magnetizing current and the frequency is not linear. While the frequency change is rather steep with small DC currents, the curve flattens out as the DC current is increased. By varying the average DC current, the centre frequency can be placed anywhere within the entire range. By superimposing an alternating current upon the direct current, a frequency sweep is produced at the AC rate. The maximum obtainable sweep width (governed by the 0 and maximum DC current) cannot be exceeded (Fig. 16) even if the attempt is made with full sweep width to displace the centre frequency from the range mid-position to a higher or lower frequency.

Mech. coupling
of sweep and
centre-frequency
control

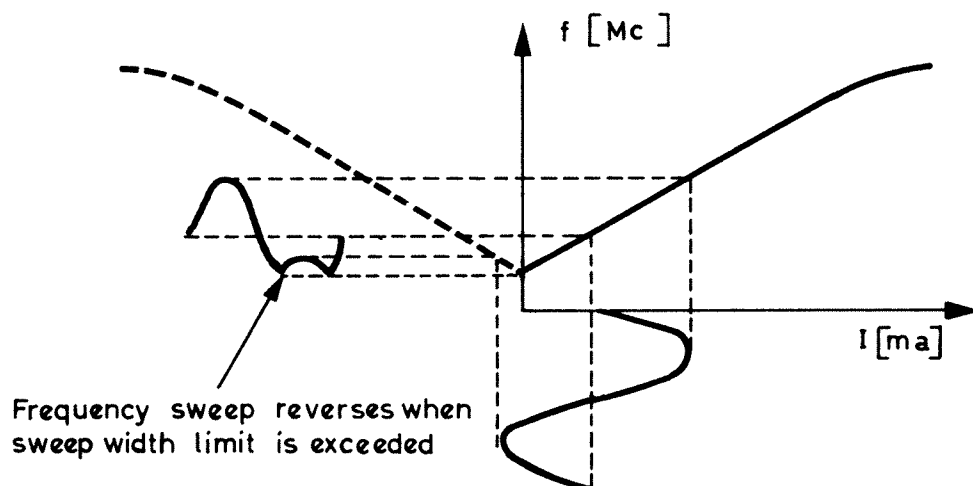


Fig. 16

The smaller the sweep width, the farther the centre frequency can be varied from its mid-range position. With extremely small sweep widths, a variation of the centre frequency over the entire range would be possible. In order to take all this into account, the controls for the centre frequency and sweep width are coupled together in such a manner that with any given sweep width, the centre frequency can only be varied through a range of frequencies that are physically practicable. If the attempt is made to adjust the centre frequency outside of the narrowed-down range, the sweep width control is automatically decreased to a proper value. This mechanical coupling over a simple steel-wire drive between the axles of the two potentiometers prevents the sweep width and centre-frequency controls from being incorrectly adjusted.

In order to obtain a scale linearly proportional to the frequency, a linearizing circuit is provided. The driver coils for each range lie in the anode circuit of valve R635. The transconductance curve is distorted in such a manner through the use of a voltage-dependent feedback in the cathode circuit that the frequency versus grid-voltage variation is practically linear. Two voltage-dependent resistors are used as non-linear elements whose effectiveness is regulated by series-connected resistors. The sine-wave sweep voltage is obtained from a resistor that lies in series with the horizontal deflection coils. A strictly linear relationship between the sweep width and the deflection of the electron beam is thereby guaranteed. In order to suppress the drifting of the centre frequency when using small sweep widths, the valve R635 is heated from a stabilized 6.3 v direct current supply.

Sweep
lineariza-
tion

The RF voltage of the first range, 0.5 to 50 Mc, is not directly produced but through mixing. The RF voltage of the swept oscillator (valve R68 L) operating in the range from 150 to 220 Mc is mixed with the output voltage of a 150-Mc fixed-frequency oscillator. (The swept oscillator delivers its voltage directly to the POLYSKOP output when the set is switched to the 150 to 220 Mc range.) The fixed-frequency oscillator (R61) is designed as a push-pull circuit in order to suppress the second harmonic. The difference frequency appearing at the mixing diode is

Band
0.5 to 50 Mc

$$\begin{array}{r}
 150 \text{ to } 220 \text{ Mc} \\
 - 150 \quad 150 \text{ Mc} \\
 \hline
 0 \text{ to } 70 \text{ Mc}
 \end{array}$$

The difference frequency is amplified by a three-stage wide-band amplifier (Rö2 to Rö7) and then delivered to the RF output of the POLYSKOP. The last of the three stages is a distributed amplifier using four valves.

Two resistive divider networks are located just before the RF output. One is switchable in 10-db steps from 0 to -60 db; the other in 1-db steps from 0 to -10 db.

Output
attenuator

A rectifier circuit (G18) is connected directly in the RF output. The rectified RF output voltage response can be viewed on the picture tube. (Selector switch for Y_1 or Y_2 in the position E_{out}).

E out
indi-
cation

Since the oscillators have a rather large amplitude response (up to 30%) as they are swept across their frequency range, it is necessary to hold the output voltage constant by means of a control circuit. This control circuit operates in the following manner: (see Fig. 17)

RF control
circuit

The RF voltage is rectified by G12 just ahead of the calibrated output attenuator. The rectified voltage is applied through R53 to the control grid of valve Rö12 (type EF 804 S) to which, through R85, R86, -85 v are also applied. The resistors R53, R85 and R86 make up a voltage divider which is so adjusted that valve Rö12 is cut off when rectifier G12 delivers no output voltage. The anode of Rö12 is connected to the grid of a double triode (Rö11, type ECC 81) which has both its halves connected in parallel. This double triode is connected in series with the anode current delivered to the switched-in sweep oscillator. When Rö12 is cut off, there is no voltage drop across R83. The grid of Rö11 becomes highly positive causing it to have a low DC anode resistance. The sweep oscillator thereby receives a high anode voltage causing it to oscillate quite strongly. G12 then delivers a positive voltage and Rö12 draws anode current. The anode voltage of Rö12 drops, thereby decreasing the bias voltage of Rö11. The valve Rö11 increases its DC anode

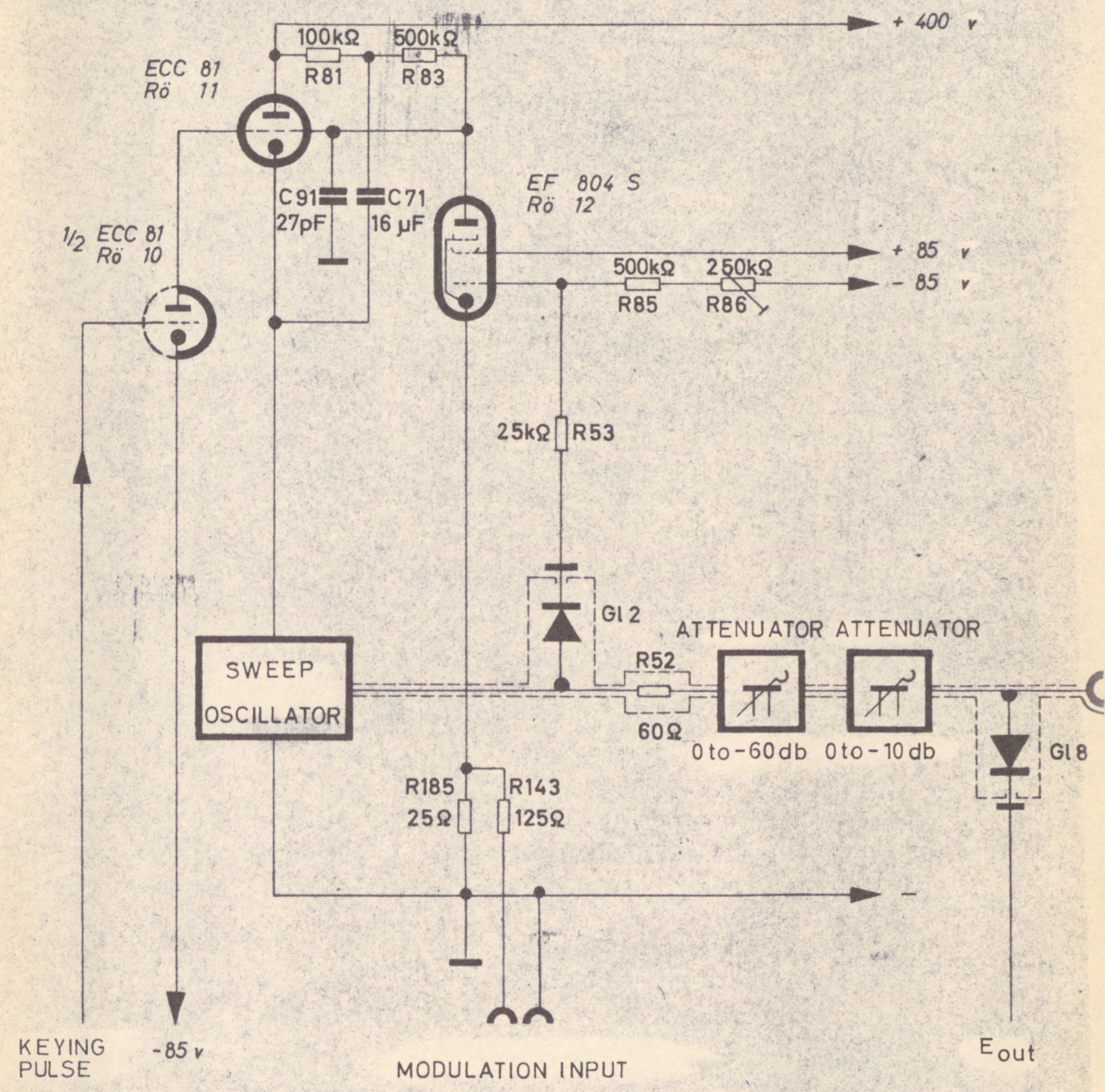


Fig.17 CONTROL AMPLIFIER AND KEYING CIRCUIT POLYSKOP

Bl. 50

resistance and the anode voltage of the sweep oscillator drops. The anode voltage and the RF voltage balance out to equilibrium. Any change of the RF voltage level is compensated through the control amplifier by changing the anode voltage to the sweep oscillator so that the original RF voltage change is opposed (backward regulation). An error signal is necessary for the functioning of the control circuit amplifier. This error signal may be smaller the higher the gain of the control circuit amplifier. The control amplifier gain is determined solely by R612 since R611 operates as a cathode follower having a gain less than 1.

In order to change R611 into a normal amplifier for fast changes (AC variations), the anode load resistance of R612 (R83) is tapped and via C71 (16 μ f) connected to the cathode of R611. The amplifier stage R611 then has a gain of approx. 10 for AC variations. A prerequisite for the faultless operation of this circuit is that the anode resistance of R612 is so high as to make the anode current through R83 independent of the anode voltage of R612. This requirement is reasonably satisfied with an anode resistance of 2 M Ω . The control amplifier compensates for slow changes of RF voltage level (for instance when frequency bands are changed) with much less accuracy than for the fast variations encountered in frequency sweeping.

Amplifier
for AC
variations

To check the operation of the control amplifier, the voltage output response of G12 can be viewed with the Y₂ selector switch placed in the position "EMF".

EMF
indication

The control amplifier not only compensates for the RF voltage level variations caused by amplitude response, AC supply variations, band switching, etc. (internal causes), but also for those which are caused by load variations. In other words, the internal resistance is very low (almost zero) as a result of the control circuit. In order to obtain a source impedance equal to a characteristic impedance of 60 Ω , a 60- Ω resistor (R52) is connected behind the rectifier G12 in the output circuit.

Signal
generator
source
resistance

The frequency sweep, horizontal deflection and oscillator keying are all synchronized to the AC supply frequency in such a way that an increase in frequency of the sweep oscillator corresponds to a horizontal beam deflection from left to right on the screen of the picture tube. The frequency at any instant corresponds to a definite position of the beam in the horizontal direction. During the flyback of the beam and frequency, the oscillator is keyed off in order to give a 0-reference line in the pattern. The oscillator must be keyed off at the maximum frequency point when the beam is in the farthest position to the right in the display. The oscillator is cut in again at the lowest frequency point to the left in the display. A square-wave voltage is necessary for keying the oscillator. The edges of the square wave coincide with the maxima and minima of the AC supply voltage.

Frequency
sweep

Horizontal
beam
deflection

Keying
off

The keying voltage is produced in the POLYSKOP by limiting the sine-wave voltage delivered from transformer Tr2. Since due to the limiting action the edges of the square wave coincide with the zero voltage points of the sine wave, the sine-wave voltage must be changed in phase by 90 degrees before limiting in order to obtain the desired phase relationship. The 90-degree phase shift is produced in the phase-shift network R73, R74, C69. R73 is used to adjust the phase shift. The sine-wave voltage is square-wave limited in the left section of R610, whose cathode lies at -85 v and whose anode is connected to the grid of the control valve R611. During the forward frequency sweep, R610 L is cut off and R611 can function normally. During the return sweep, R610 L is conducting, which drops the anode voltage to a low value (about 30 to 40 v) because of the high anode load resistance (R83 = 500 k Ω). Since the cathode of R610 L lies at -85 v, the anode of R610 L has a potential of about -40 to -50 v with respect to earth. The anode of R610 L is connected to the grid of R611, which gives them the same potential. R611 is thereby fully cut off and the sweep oscillator stops oscillating.

Generation
of keying
voltage

For special measuring problems, it may be useful to amplitude-modulate the RF output signal. For this purpose, a modulation input is provided. The modulating signal is applied to the con-

Amplitude
modulation
of RF
signal

trol amplifier whose feedback action makes it possible to produce an almost distortion-free modulation up to about 30%.

5.2 Display Section

The display section has the purpose of displaying the amplitude response of various test items as a function of the sweep oscillator frequency. RF signals must be changed into their proportional DC values before they can be displayed. It is therefore necessary to have additional equipment for measuring reflection coefficients, response curves, etc. which produce DC voltages by simple rectification.

For this purpose, the RF terminated measuring head is provided. The RF signal, which has passed through the test item, is passed on to the terminated measuring head and may be displayed by placing the Y_1 selector switch in the position "RF". For signals that are already rectified in the test item (for example, the demodulator of a receiver or a diode probe), separate vertical-deflection amplifier inputs are provided. Since the demodulated signal of a test item may be either positive or negative, the polarity of the vertical-deflection amplifier inputs may be selected for either positive or negative signals so that an upright picture may always be presented. In order to have the possibility of observing two voltage variables simultaneously, the double-channel vertical deflection amplifier system is provided with an electronic switch.

RF input

Vertical-
deflection
amplifier
inputs

The vertical-deflection amplifiers must have a few special characteristics not found in normal oscilloscope amplifiers. When tracing a linear frequency response curve, the input voltage to the amplifier is a constant value during the forward trace and zero during the return trace. The forward and the return trace each lasts 10 msec. The amplifier must then be able to handle a square wave at the AC supply frequency without any noticeable sag. The lower limit frequency must be extremely low (approx. 0.2 cps). The time constants of the coupling circuits lie at 1

Vertical
deflection
amplifiers

sec and even higher. A voltage stabilizer cell ("Neumannzelle") is connected as a cathode resistor to provide the bias voltage for the first stage. This cell has an equivalent capacitance of 40,000 μ f. The screen-grid voltage is produced by a relatively low-resistance divider network that uses no bypassing.

The next stage (Rö21 and Rö15 Type ECC 81) is a phase splitter that produces two signals of opposite polarity. The polarity may be selected by means of relay RLS 6 and RLS 7, respectively. The following stage is again a double triode with a common cathode resistor. In the left section, the signal is amplified; the right section serves as cathode follower for the switch-over pulse in dual-beam operation. Up to this stage, both channels Y_1 and Y_2 are identically constructed. The electronic switching in dual-beam operation is accomplished by Rö22 and Rö16. The anodes of the left sections of these valves are connected together and have a common anode load resistor. The grids of the right sections are each connected to one of the switch-over pulses delivered from a bistable multivibrator (Rö23). In normal oscilloscopes, the vertical-deflection amplifier is usually designed as an AC amplifier which is fully adequate for displaying symmetrical signals. The situation is different in the case of oscilloscopes designed to display the response curves obtained by the sweep frequency method. Not including exceptions (discriminator curves), the oscillograph pattern is displayed to one side of the 0-reference line, i.e. the signal is not symmetrical and contains a DC component. If the DC component is not passed through the amplifier, the 0-reference line has a position that is dependent upon the content of the signal displayed. For example, if during an alignment procedure the height or width of the displayed response curve changes, the 0-reference line is displaced vertically. This is very disturbing when trying to evaluate a displayed quantity on a graticule.

Selectable
polarity

Electronic
switching

In order to avoid this disadvantage, a symmetrical clamping circuit is used which is keyed in synchronism with the sweep frequency. During the flyback period, the resulting 0-reference line is held exactly to a definite voltage level. Rö17 (Type EAA 91) serves as the clamping diode. After the signal is clamped, it

Clamping
circuit

cannot be permitted to pass through any more RC-coupling networks. For this reason, the last two stages are designed as a DC amplifier (Rö18 R and Rö19). The vertical deflection coils L 32 lie in the anode circuit of Rö19 (Type EL 84).

Negative
deflection
current

Since the anode current flows only in one direction in a valve, it is possible to deflect an electron beam only in one direction from the picture-tube middle. In order to utilize the entire screen for the display, a current is passed through the deflection coils that has the opposite direction to the current passing through the valve Rö19. This current is fed in through R164 and L42 and deflects the beam somewhat over the lower edge of the screen. In this manner the beam may be deflected over the entire picture-tube screen with the anode current of Rö19. The current for the negative deflection of the beam is supplied from the unstabilized HT voltage of the electronically stabilized power supply (approx. 400 v). This voltage is naturally subject to AC supply voltage variations, which affects the negative deflection current. The picture-tube pattern would be displaced in the vertical direction with AC supply voltage variations. In order to eliminate this undesirable effect, a small additional current is brought over from the HT voltage through R188 and fed into the anode circuit of Rö18. Any change in the HT voltage causes a change of operating point, thus changing the anode current of Rö19 which counteracts any change in the negative deflection current.

Clamping circuit and electronic switch.

Clamping
circuit

As already mentioned, the clamping circuit serves to fix the 0-reference voltage level. The circuit operates in synchronism with the frequency sweep and is controlled by the oscillator keying voltage. This keying voltage is taken from the grid of the keying valve (Rö10 L) and fed to the grid of Rö25 R whose cathode lies at -85 v potential, the same as Rö10 L. The anode of Rö25 R is connected to the grid of Rö25 L whose anode circuit resistance is made up of two equal resistors; one connected to the anode, the other to the cathode. The keying pulse brings Rö25 R into conduction. Because of the high anode load resistance, the anode voltage drops to a low value (approx. 30 v).

b

Since the cathode lies at -85 v, the anode of R625 R drops to about -50 v with respect to earth. The grid of R625 L also has the same potential of -50 v which drives it into cutoff. The anode voltage of R625 L rises toward 250 v and the cathode voltage drops to earth or 0 v. When the keying voltage is removed (during the forward sweep), R625 R is cut off. The grid of R625 L rises to the anode supply potential through the anode load resistor R194. R625 L conducts. Two square-wave voltages of opposite phase are available at R625 L, which are in phase with the keying voltage. These square-wave voltages are applied to the series-connected diodes in R617 through capacitors C83 and C84. The diodes rectify the square waves; a pulsating DC voltage is created across potentiometer R168. The phase relationship is so chosen that the diodes are conducting when the sweep oscillator is cut off during the flyback. Since the diode forward resistance is quite low, all of the electrodes of the duodiode have practically the same voltage level, namely the level adjusted at R167 which is applied to the arm of potentiometer R168. Any difference in diode characteristics can be compensated with R168. The point of common connection between the diodes is connected to the input grid of the DC amplifier (R618 L). During the clamping action, this grid is connected to the voltage level adjusted at R167 through the low resistance of the conducting diodes. The grid has thereby a definitely fixed potential during the flyback giving a definite position to the 0-reference line on the picture tube. During the forward sweep or trace, the diodes are cut off so that the grid of R618 L can be driven by the signal without being influenced by the diode circuit. Since there is no grid resistor, a coupling capacitor (C82) of 1000 pf is sufficient in spite of the extremely low limit frequency. A grid resistor is not necessary since wandering of the grid potential is not possible as a result of the clamping action.

DC amplifier

In dual-beam operation, the two signals delivered by the amplifier are alternately switched in so that the signals are displayed every other frequency sweep. This is noticeable in the display by a decrease in brightness accompanied with flicker. The switch-over from one channel to the other is always accomplished at the end of the forward sweep. The clamping circuit

Electronic switching

then has sufficient time (10 msec) to charge the coupling capacitor C82 to the 0-reference level of the other signal. The switch-overs occur at $1/2$ the AC supply frequency.

The switch-over pulses are produced in the following manner:

The clamping pulses are taken from the cathode of R625 L and coupled to the grid of R624 R through capacitor C94. In valve R624, the pulses are amplified and limited. The square-wave pulses are differentiated with the RC network of C99-R207 and fed to R624 L. R624 L is normally cut off by the negative voltage obtained from the voltage divider R206-R207. Only the positive peaks of the differentiated square-wave cause the valve to conduct and produce a negative needle pulse across the anode resistor R208. Since the anode voltage of the bistable multivibrator R623 is taken from the anode of R624 L, the multivibrator is triggered. The bistable multivibrator (flip-flop) has two stable conditions, i.e. one valve section is conducting while the other is cut off. The system changes from one stable condition to the other with every trigger pulse. The circuit is so designed that at the point between R165 and R199 the voltage varies between -15 v and +50 v with respect to earth. At the point between R204 and R205, the same voltages appear, but with opposite polarity. R616 R and R622 R are both driven with these voltages. For example, if the grid of R622 R lies at -15 v, this section is cut off and R622 L can operate as a normal AF amplifier. If the grid lies at +50 v, R622 R conducts a heavy anode current and its cathode potential rises to about +55 v. The cathodes of both sections of R622 are connected together, therefore R622 L has a bias voltage of approx. -50 v (grid voltage to earth, about +8 v). This cuts the valve off even for signals with large amplitudes. The same is true for the functioning of R616. The input signals are alternately delivered to the common anode load resistor R138. If one of the amplifier channels is shut off, the electronic switch becomes superfluous. One of the cathodes of R623 is switched off so that the appropriate system is not conducting and the multivibrator does not respond to the trigger pulses. The unused channel remains cut out of operation. The cathodes of R623 and R624 are connected in pairs so that when

Generation
of switchover
pulses

Electronic
switching

one cathode of R623 is switched off, so is one of the cathodes of R624. In this manner, the trigger itself, which is bothersome in single channel operation, is also switched out.

5.3 The Marker Generator

The marker generator is used for frequency orientation when evaluating an oscillogram. 1-, 10- and 50-Mc markers may be selected.

The crystal oscillator with R626 L is connected in a Colpitts circuit which generates a 1-Mc and a 10-Mc fundamental frequency. The crystals are changed by relay RLS 4. The generated oscillations are amplified in R626 R, whose anode circuit is switched between a 1-Mc and a 10-Mc tuned circuit. The 10-Mc circuit contains no special capacitor, the valve and wiring capacitances being used.

Generation
of the
fundamental
frequencies

The oscillator with R626 R is switched over to a Colpitts oscillator generating a 50-Mc frequency by means of relay RLS 5. (C113-L36-C114). The 10-Mc tank coil L35 is then used as an anode choke while R626 L is out of operation. The generated frequency is fed to R627 which operates as a harmonic generator. The diode G110 connected in parallel to inductor L37 aids in the harmonic generation. In R628 the signal is again distorted by harmonic generation. The harmonic spectrum now reaches up to 400 Mc and is fed to the mixing diode G112. A small part of the signal-generator output voltage is coupled out through R51 for mixing. Each time the signal-generator frequency passes through a harmonic frequency, interference is produced. This beat frequency is amplified through the two stages of R629. The RC network of C133/R248/C134/R247 as well as C132/R251 is used to produce a favourable marker form. The markers are amplified once more by R618 R and coupled into the vertical deflection amplifier channel through C85.

Harmonic
generation

Marker
mixing

Marker
amplification

5.4 Power Supply

The valve filaments are heated with an unstabilized AC voltage of 6.3 v, except for Rø8, Rø9 and Rø35. There are three circuits used to supply the necessary filament current. One side of the filaments in the signal generator section is connected to the chassis so that the filament current is carried by a single conductor from the winding 5-6 of Tr1. The filament current for the vertical-deflection amplifier section is carried by two conductors from winding 3-4, with the filament circuit being earthed through one conductor. The cathodes of valves Rø11, Rø30 and Rø31 have a high DC potential over earth. These valves are supplied from a separate filament winding 1-2 which is not fixed at any potential. However, due to small currents through the cathode-filament insulation, the filament winding approaches the cathode potentials.

Heating

The RF generator valves Rø8, Rø9 and Rø35 are heated from a stabilized DC supply to increase the valve life and provide a higher stability. Approximately 12 v are obtained from the bridge-rectifier G113 which is connected to winding 15-16 of Tr1. This voltage is fed to a transistor stabilizing network comprising T1, T2 and T3. The reference voltage for the voltage stabilization is provided by a Zener or breakdown diode G114. The adjustment of the heater voltage to 6.3 v is made with potentiometer R258.

RF generator
heating

Stabilized
heater
circuit

The anode supply voltage (approx. 205 v) of the valves in the signal generator section and marker generator is not stabilized. This voltage is provided by G15-C61-L30-C62. Stabilization is not necessary since the EMF control circuit holds the RF output voltage constant anyway.

Anode
supply
voltage

The anode voltage of the display section (250 v) is electronically stabilized by the circuit containing Rø30, Rø31, Rø32 and Rø33. The stabilizer network only compensates variations in the output voltage; therefore, only the output voltage needs to be adjusted.

The HT voltage (approx. 400 v) feeding the regulator circuit is supplied through the bridge-rectifier G14. The negative sides of the filter capacitors are not earthed, but connected to corresponding points on the plus side of the 205-v anode voltage supply. By this means, normal electrolytic capacitors with a working voltage of 250 v may be used in spite of the 400-v HT voltage.

HT voltage

The high voltage for the picture tube (approx. 4 kv) is produced by a voltage-doubler circuit using cartridge-type selenium rectifiers which are supplied with 1.7 kv AC. The filtering is accomplished with C57-C58; the resistors R65-R66 serve to discharge the high-voltage capacitors after the set is shut off.

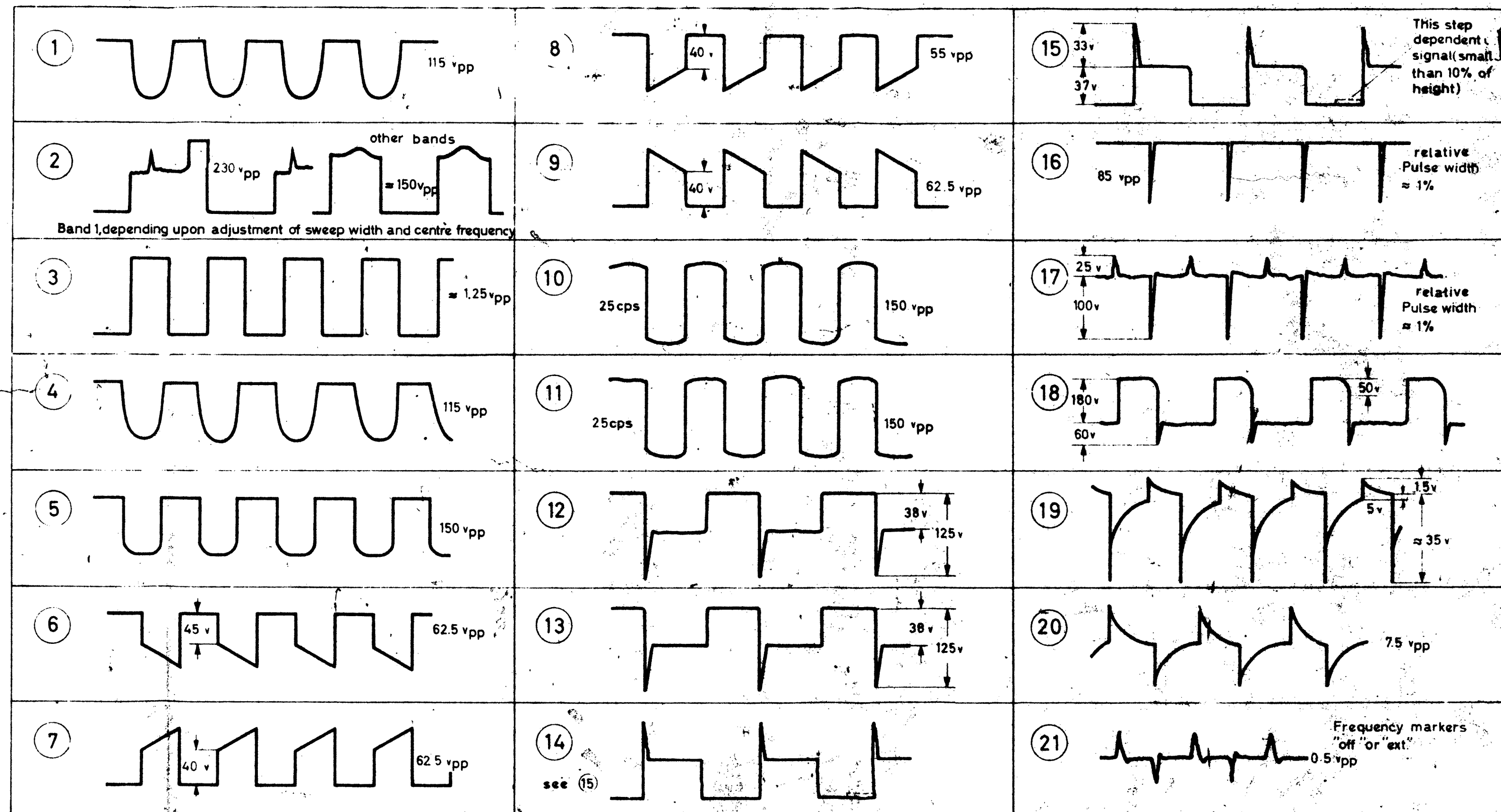
High voltage

The -85 v which is necessary at several points in the set is supplied with the circuit comprising G16-C67-R72-C68. This voltage is stabilized with the reference tube R834 (Type 85 A 2).

Negative
voltage

A blower is built in at the rear of the set which provides protection against excessive temperatures during prolonged operation.

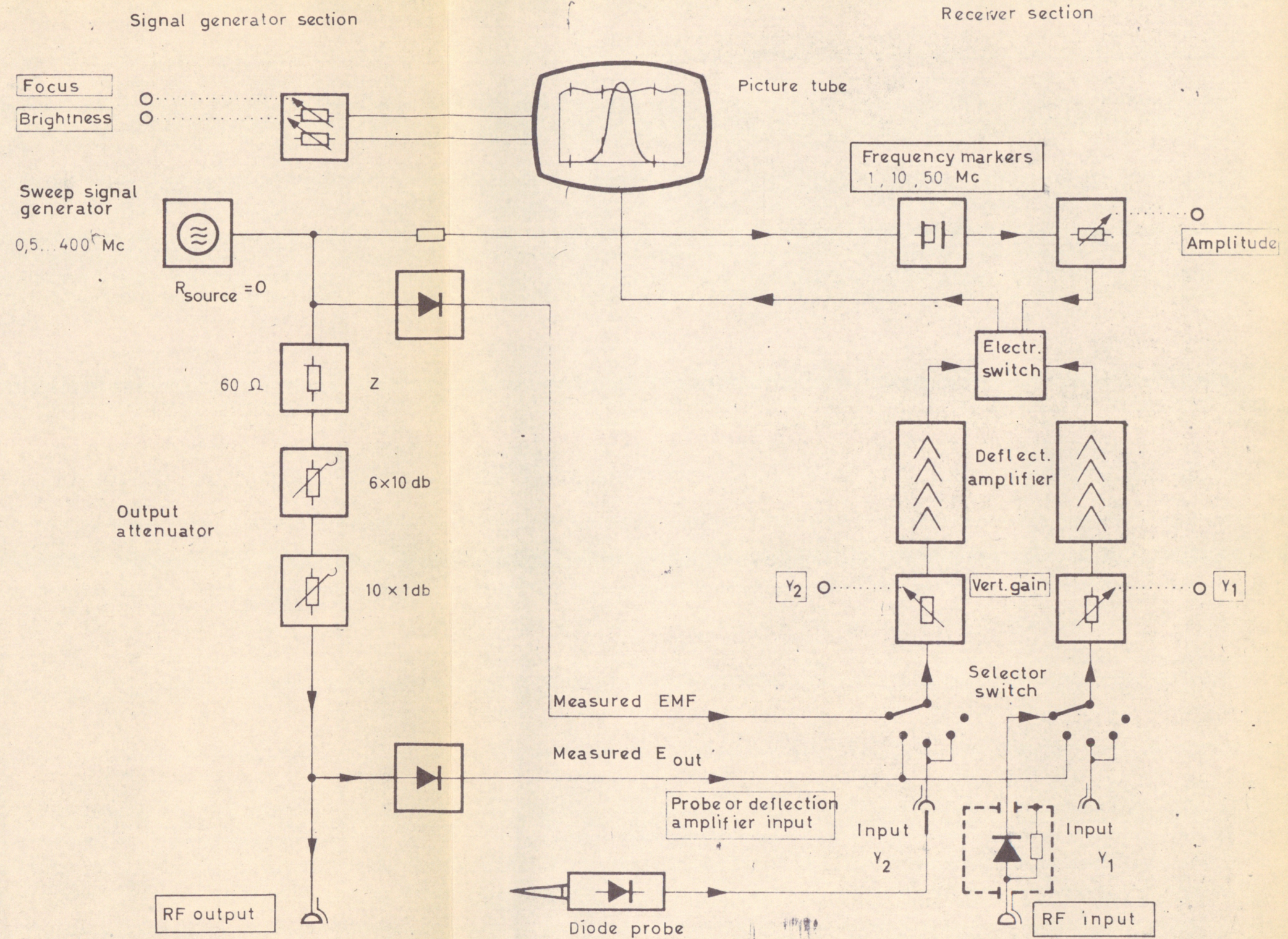
Blower



Bl. 6-1

Fig. 18 WAVE FORM CHART

POLYSKOP



Bl. 62

Fig. 19 Block diagram

6. Specifications

6.1 Sweep Signal Generator

Frequency range	0.5 to 400 Mc
in five bands	0.5-50, 50-150, 150-200, 220-310, 310-400 Mc
Overlapping of the bands . . .	more than 10 Mc (5 Mc between sub-ranges 1 and 2)
Sweeping	
Sweep width	± 0.5 to ± 50 Mc about centre frequency but not beyond band limits; continuously variable
Centre frequency	adjustable within the bands
Frequency sweep	sine wave, rising; retrace blanked
Amplitude modulation	possible in addition to sweeping
Frequency range	50 cps to 20 kc
Modulation depth	max. 30%
Voltage requirement	approx. 70 mv/% modulation
Input impedance	150 Ω
Input	4-mm telephone jacks (rear connection) single-ended
Output voltage	0.5 v_{rms} when match-terminated ($Z_o = 50 \Omega$ 0.4 v_{rms}) built-in attenuators for 10-db steps up to 60 db and 1-db steps up to 10 db
Flatness of output level of swept RF frequency within the band limits	within 0.1% per Mc sweep width when match-terminated.
Flatness of EMP within the band limits	within 0.05% per Mc sweep width
Distortion	less than 5%
Source impedance	50 Ω for BN 4244/50 60 Ω for BN 4244/60 75 Ω for BN 4244/75
Output	R&S connector Dezifix B

<u>6.2 Display Section</u>	two identical, independent channels electronically switched at one-half the sweep frequency, gain continuously variable
Inputs	(1) coaxial RF input with built-in terminating resistor and detector (2) two RF diode probes (3) two deflection amplifiers
RF input	50, 60 or 75 Ω dependent on BN; detector isolated from DC
Frequency range	0.5 to 400 Mc (usable to 1000 Mc)
Sensitivity	50 mv for full picture height
Reflection	less than 3% up to 400 Mc
Power rating	max 1 w, RF plus DC
Connector	R&S connector Dezifix B
RF diode probes	
Frequency range	0.5 to 400 Mc
Sensitivity	30 mv for full picture height
Voltage rating	max. 10 v
Input impedance at 300 Mc	20 k Ω shunted by 3 pf; withstands DC up to 500 v
Connection	to deflection amplifier input sockets
Probe without coloured mark	negative signal, detector circuit earthed
Probe with red mark	positive signal, detector circuit floating
Deflection amplifier inputs	for circuits under test which contain a detector
Frequency range	3 cps to 7 kc
Sensitivity	2 mv for full picture height
Polarity	positive or negative
Input impedance	500 k Ω ; withstands DC up to 500 v
Connectors	coaxial 13-mm sockets

<u>6.3 Picture Tube Assembly</u> . . .	oscilloscope for simultaneous presentation of two quantities by electronic switching
Size of screen	280 x 210 mm, 36-cm picture tube with magnetic deflection
Quantities measured, separately selectable for each channel	output voltage of sweep signal generator; voltages of circuit under test applied to RF input or RF diode probes or vertical-deflection amplifier inputs, EMF of sweep signal generator for performance check
Frequency axis	horizontal
full width of picture	equal to sweep width of sweep signal generator
Calibration	by frequency markers
Frequency markers	internal and/or from ext. frequency; variable in amplitude; independent of circuit under test
internal	crystal-controlled; at 1 or 10 Mc; 50 Mc for orientation (free running), switch-selected
external	frequency of an external signal generator; voltage requirement approx. 1 v _{rms} , input: R&S connector Dezifix B on the rear, 60 Ω , usable for generators of 50, 60 or 75 Ω .
Voltage axis	vertical; zero reference line can be vertically shifted over full height of screen
Voltage indication characteristic	approx. square law (RF inputs); dependent on rectifier circuit under test at deflection amplifier inputs
Voltage reference lines	provided at linear sub-divisions on replaceable illuminated plexiglass graticule
Calibration	by reduction of the sweep signal generator voltage by the built-in attenuators
Range of attenuation and gain measurements	45 db for attenuation; 60 db for gain, extendible by attenuator pads

Accuracy ± 0.1 db.

Response curves that change in amplitude from 10% to 100% of max. value within 20 kc of sweep width can be fully resolved.

6.4 Common Data

Power supply 115/125/220/235 v $\begin{smallmatrix} +10\% \\ -10\% \end{smallmatrix}$,
47 to 63 cps (150 va)

Valves, etc.

Valves 2 valves E 88 CC
8 valves E 180 F
1 valve EAA 91
13 valves ECC 81
2 valves EF 86
2 valves EF 804 S
1 valve EL 84
2 valves EL 86
1 valve EL 95
1 valve MW 36 - 44 (or 14 M 10 P 4)
2 reference tubes 85 A 2
Transistors 2 transistors OC 604 spec.
1 transistor CTP 1109
Scale lamps 2 scale lamps RL 165 S
1 scale lamp RL 215
Fuses 1 fuse 1 amp for 220/235 v
Dimensions (W x H x D) 540 x 370 x 575 mm
(steel cabinet with cover)

Weight, accessories included approx. 55 kg

6.5 Accessories, included in the price

- 1 power cord R&S Stock No. LK 333
- 1 RF diode probe earthed BN 42443
- 1 RF diode probe off earth BN 42444 (marked red)

- 2 spare tips (for diode probes)

- 1 coaxial cable with 2 Dezifix B connectors
 - 50 Ω E 4244/50-48
 - 60 Ω E 4244/60-48
 - 75 Ω E 4244/75-48

6.6 Recommended Accessories (on separate order)

Precision extension cable with Dezifix connector

- 50 Ω , approx. 50 m in length BN 356815/50
- 60 Ω , approx. 50 m in length BN 356815/60
- 75 Ω , approx. 50 m in length BN 356815/75

Coaxial 13-mm plugs, R&S connectors Dezifix B, adapters from Dezifix B connector to other makes, cables for 13-mm plugs, Dezifix cables, attenuator pads, matching pads for various characteristic impedances, baluns.

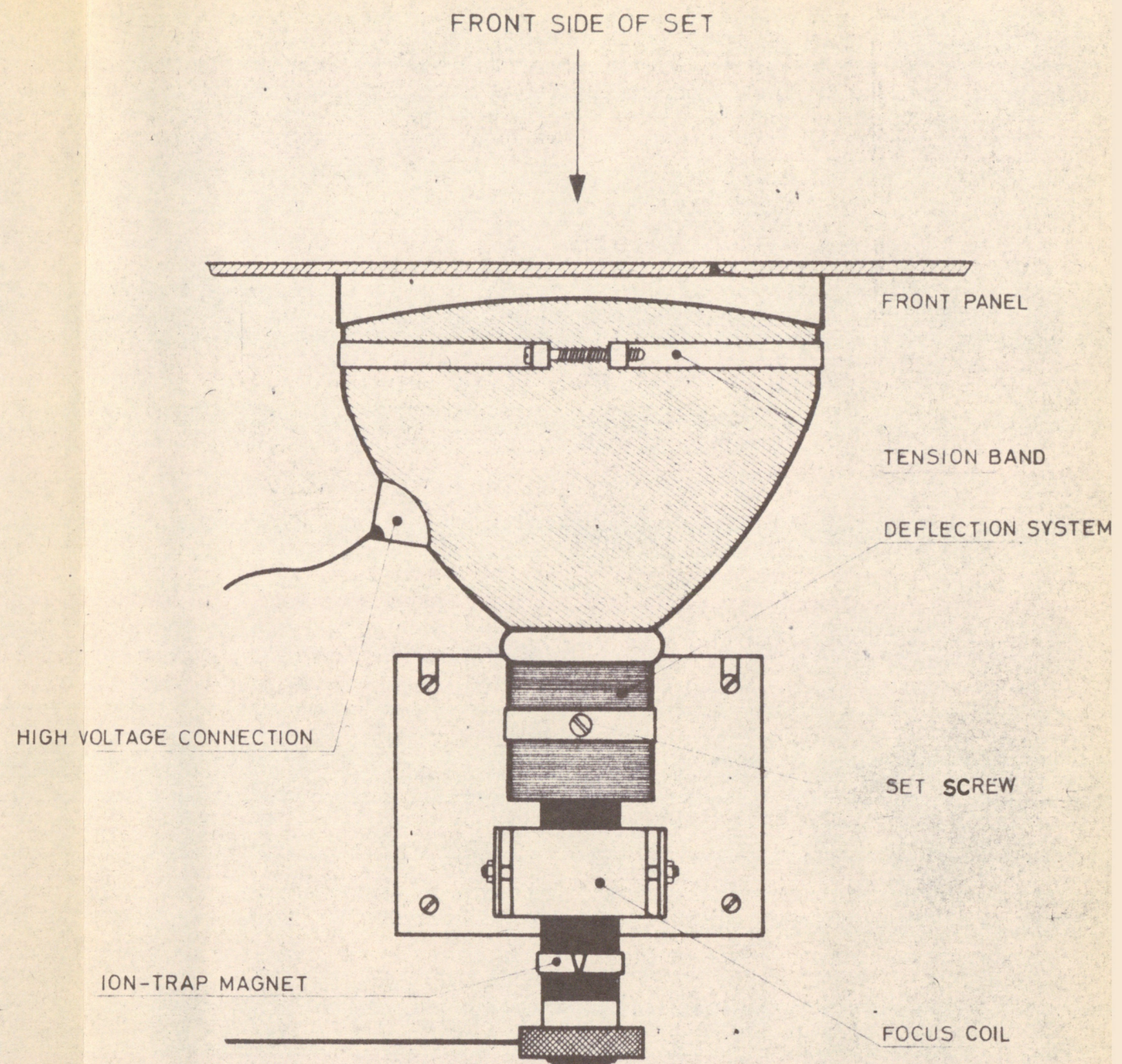


Fig. 21 POSITION OF PICTURE TUBE

BL 68

7. Maintenance of the POLYSKOP

7.1 Picture Tube

A normal TV picture tube is used in the POLYSKOP for the display. The steel cabinet and the 5-mm plexiglass protector offer a protection against a possible damaging of the picture tube.

The picture tube must support a force of several tons of atmospheric weight. If the glass enclosure is damaged by shock, forceful impacts, or even scratches, an implosion may result that can seriously injure persons standing nearby. It is dangerous to use or set up the POLYSKOP anywhere without the steel cabinet or plexiglass protector. When cleaning the plexiglass protector or making repairs where the POLYSKOP is removed from its cabinet, face and hands should be protected with a face guard and gloves. These precautions are especially important when a new picture tube is being mounted. If the equipment must be left without a cabinet for a prolonged period, a linen cover should be placed over the set.

7.2 Replacing the Picture Tube (see Fig. 21)

The set must be shut off for at least 10 minutes so that the high voltage of 4 kv has definitely dropped to 0. However, we recommend that the high-voltage cable be disconnected and short-circuited to earth. In addition, the high-voltage aquadag connector on the picture tube should be earthed with a piece of wire in order to remove any remaining charges.

When replacing the picture tube, the above mentioned precautions are to be especially observed. Without using any force, the picture tube may be removed from its socket. Remove the ion-trap magnet located between the tube base and the focus coil by pulling back. Loosen the mounting screws which fasten the entire deflection system to the chassis. After removing the multi-pin connector, the deflection system can be removed from the rear of the set. Then support the neck of the picture tube with a soft rag. Finally, loosen the tension band near the face of the tube and remove the picture tube from the top of the set.

The picture tube should never be held by the neck alone or even turned. One should always carry the picture tube with its face downward in the flat of the left hand while the neck is lightly held with the right hand. The picture tube may then be set upon a soft surface and secured against tipping.

The new picture tube is then mounted using the reverse procedure.

7.3 Adjusting the Ion-trap Magnet

Push the ion-trap magnet on the tube neck so that the arrow points to the tube base (pin 9). Turn the set on and advance the intensity control fully clockwise. By moving the ion-trap magnet forwards and backwards in addition to turning it, an indication of the beam is obtained. Turn the intensity control back while adjusting the ion-trap magnet to maintain the highest intensity.

7.4 Adjusting the Display Position

An inclination of the displayed oscillogram may be corrected with the deflection coils. First loosen the screw on the holding band of the deflection coil assembly and push this assembly as far as possible in the direction toward the face of the picture tube. By rotating the deflection coils, the horizontal position is adjusted. A separate adjustment of the vertical and horizontal deflection coils is not possible or necessary.

7.5 Adjusting the Focus Coil

The focus coil is located between the deflection coils and the ion-trap magnet. The focus coil may be adjusted in all directions after the two screws to the chassis and the nuts on the side have been loosened. The coil is adjusted until the displayed 0-reference line is perfectly straight and the beam does not disappear from view at the edges of the screen. You should be careful that no point of the inner surface of the focus coil comes closer than 1 mm to the neck of the picture tube. In no case should the focus coil be permitted to touch it.

The focus coil and ion-trap magnet cannot be adjusted without interaction. As a last step, the ion-trap magnet must once again be adjusted for maximum intensity of the beam. The set is placed into its cabinet after all the loosened screws have been tightened.

7.6 Replacing the Valves in the POLYSKOP

All valves in the POLYSKOP can be replaced with the same type of replacement valves without affecting the operation of the set.

7.7 Replacing the Transistors

The power transistor T3 is mounted on a cooling plate located underneath the RF output connector. Note that the cooling plate is isolated from the chassis and has approx. 12 v DC with respect to earth. Bits of metal or screws may cause a short-circuit that can lead to the destruction of the rectifiers.

The two transistors T1 and T2 and the Zener or breakdown diode G114 are accessible after removal of the mount for the heater voltage control, potentiometer R258, located under the picture-tube chassis mount. The replacement transistor must be soldered in.

After replacing the transistors or the breakdown diode, a readjustment of the stabilized heater voltage is necessary (see paragraph 8.2).

7.8 Replacing the Graticule Illumination Lamps

To replace the two small , tubular lamps which serve to illuminate the graticule, the plexiglass protector must be removed by pulling it out at the top. After the plexiglass protector has been removed, the two molded phenolic wedges located above the lamps in the protector guiding tracks may be tilted inward so that the lamps can be removed from the outside. To remove the lamp at the right-hand side, the screening cover which covers the vertical-deflection amplifier inputs must be removed. The AC pilot lamp may be replaced with a normal screw-base lamp.

7.9 Replacing and Cleaning the Graticule

After the set is removed from its steel cabinet, the plexiglass protector containing the graticule may be pulled upward out of the guiding tracks. The face of the picture tube may only be cleaned with a dampened soft rag. The same is true for the plexiglass protector, which is quite easily scratched.

7.10 Hints for Proper Operation

7.10.1 Operation from Low AC Supply Voltage

The POLYSKOP operates perfectly from voltages that deviate from the nominal value by up to $\pm 10\%$. However, a supply voltage of -10% from nominal value should be avoided for continuous operation since certain valves may fail too soon because of overloading.

7.10.2 Overloading the Oscillator Valves

In the first range 0.5 to 50 Mc, with the sweep width control turned to minimum and the centre frequency control turned to maximum, an output frequency greater than 50 Mc is produced, which lies outside the limit frequency of the wide-band amplifier. The frequency is therefore no longer passed. The EMF control circuit attempts to hold the output voltage constant and feeds the maximum anode voltage to the oscillator valves used in this frequency range. In particular valve R68 is overloaded and may suffer damage.

8. Repairing the POLYSKOP

(see Circuit Diagram and Table of Replaceable Parts)

You are asked to obtain help from our nearest representative in case of any malfunctioning of the set. Repairs should only be made in emergencies without a factory representative. The most important procedures for making alignments are compiled in the following paragraphs.

The locations of the adjustments are shown in the sketches of Fig. 23.

8.1 Adjusting the Regulated Anode Supply Voltage

The regulated anode supply voltage is adjusted to +250 v with R218. The voltage is measured from the cathode of valve R630 or R631 to earth.

8.2 Adjusting the Regulated Heater Voltage

The regulated heater voltage should be 6.3 v. It is adjusted to this value with R258. The voltage is measured at one of the oscillator valves R68 or R69 after opening the left side of the chassis.

8.3 Testing the Voltage Values

The voltage ratings are given in the circuit diagram for the most important points in the POLYSKOP circuit. These voltages should be measured with a high-impedance voltmeter such as the ROHDE & SCHWARZ Type URI or URU or a similar type vacuum-tube voltmeter.

8.4 RF Oscillators

The four RF oscillators in the left-hand side of the POLYSKOP are adjusted at the factory and secured with lacquer. We emphatically recommend that no changes be made on the tiny oscillator coils which are wound on a special ferrite core. Frequency range changes cannot occur from replacing the oscillator valves.

If the lowest range 0.5 to 50 Mc does not function properly, the frequency of the fixed oscillator may be adjusted with trimmer C12. The frequency should lie around 150 Mc. The output coupling loop of the oscillator (R01) is pushed only close enough to the tank circuit so that the EMF indication response is flat up to 50 Mc with the output attenuator set at -20 db. A coupling that is too high results in an inadmissibly high distortion which is caused by overdriving the mixing diode G11.

8.5 Setting the RF Output Voltage

The RF output voltage of the POLYSKOP is adjusted at the factory with the control R86 so that, with the output attenuators set at 0 db, the output voltage is $0.5 v_{rms}$ when connected to a resistor equal to the source resistance, i.e. with matched conditions. The adjustment is made with the help of a wide-band oscilloscope. The POLYSKOP is adjusted to a small sweep width in the lowest frequency range between 1 and 3 Mc which are frequencies that can be displayed on the oscilloscope without fall-off. The display amplitude of the RF signal should have $1.4 v_{rms}$.

8.6 Replacing the Measuring Diodes

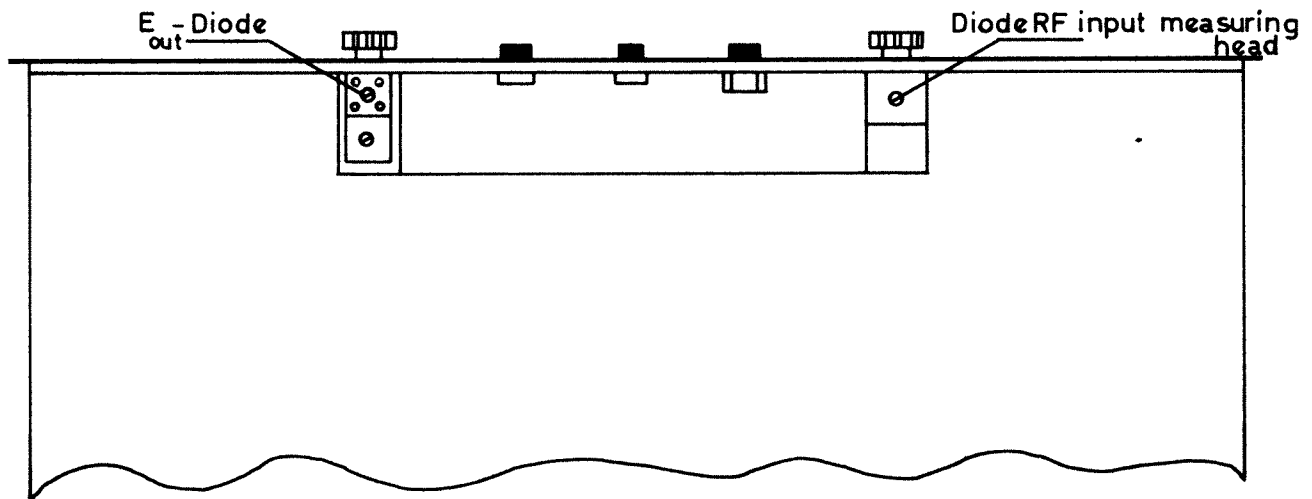
8.6.1 Control Diode

The location of the control diode G12 can be seen from Fig. 23. The diode may be replaced with the same type. It is necessary to pay particular attention to the polarity. (Commercial cartridge-type diodes are available that have a reversed polarity).

8.6.2 Diodes Located in the RF Output and RF Input Measuring Heads

After removing the set from its cabinet, the output and input measuring heads are accessible through an opening in the bottom plate. The screw caps nearest to the front panel (Fig. 22) are removed with a screwdriver. The diodes can then be replaced with ones of the same type.

Fig. 22



8.7 O-Reference Line Adjustment

If the O-reference line is not level or has a sag, the focus coil must be repositioned (see paragraph 7.5). If the O-reference line has a double trace, this may be corrected with potentiometer R168 (Fig. 23).

The adjustment is made as follows:

- (1) Remove valve R619 (type EL 84) from its socket.
- (2) Adjust the O-reference line with R164 to slightly under the lower edge of the picture screen.
- (3) Now replace valve R619.
- (4) Adjust the O-reference line to the centre of the screen with the O-LINE control and potentiometer R167.
- (5) Adjust R168 so that the O-reference line does not appear as a double trace.
- (6) Finally, the control range of the O-LINE control is adjusted with R167 so that the O-reference line is adjustable from the lower edge of the screen up to slightly above the screen centre.

You should not leave the O-reference line in the upper part of the screen for prolonged periods because of the overloading of valve R619.

8.8 Equal Display Amplitudes for Positive or Negative Signals

The two potentiometers, R150 for the Y_2 -deflection amplifier, and R152 for the Y_1 -deflection amplifier, are provided for adjusting equal gains for positive or negative signals in the two amplifier channels. These potentiometers are accessible after the right-hand cover plate is removed. In general, any gain difference is caused by a defective valve, RÖ15 or RÖ21.

8.9 Marker Generator

If the marker amplitudes are insufficient, especially in the upper frequency ranges, it may be necessary to replace the marker mixing diode G112. The diode mounted in clips near valve RÖ20 is accessible after the chassis covering plate on the right-hand side is removed.

If the 1-Mc or 10-Mc marker spectrum fails to appear, the respective crystal should be checked and replaced if necessary. The two crystals are mounted in plug-in receptacles located inside of the set near RÖ26.

The 50-Mc markers are produced in the tank circuit containing L36. When the valve RÖ26 is replaced, it is possible that the 50-Mc markers do not coincide exactly with the corresponding 10-Mc markers.

A correct marker position may again be established by adjusting the tuning slug of coil L36. The adjustment is best carried out in the upper frequency range around 350 Mc.

8.10 Adjusting the Display Width

The width of the display can be adjusted with potentiometer R68, the adjustment being made at the nominal AC supply voltage. The display width is best adjusted to about 1 cm beyond the limits of the graticule X-co-ordinates, thereby assuring a full display width even with a low AC supply voltage.

b

8.11 Adjusting the Keying Phase

The keying of the sweep oscillators must be phased correctly so that during the return trace of the display, a 0-reference line is produced. The phase

position of the keying pulse can be adjusted with potentiometer R73. The adjustment is best made with a reduced display width, the correct position of the keying pulse being especially observable.

An adjustment of the keying phase may be necessary when the POLYSKOP is used at another AC supply frequency, i.e. different from 50 cps.

8.12 Adjustment of the Sweep-Width Linearity

The 10-Mc marker spectrum is used most advantageously for observing the linearity of the sweep width.

In case the adjustment of the linearity should prove necessary, this can be accomplished with the variable resistors R261, R262, and R263. These three resistors are so adjusted that the distances between the frequency markers are as equal as possible, but in no case more than the ratio 1:2 different from one another. This adjustment should be checked in all frequency ranges and, if necessary, so corrected that the linearity of the sweep width is as equally good in all ranges as possible.

R261 affects the marker distance at the left-hand side of the screen.

R262 affects the marker distance from the middle up to the right-hand side of the screen.

R263 affects the marker distance at the far right-hand side (usually turned completely clockwise).

R264 not in use.

The adjustment of the centre-frequency and sweep-width control ranges can be affected by the adjustment of the sweep-width linearity. The range of the centre frequency and sweep width should therefore be rechecked after completing the sweep-width linearity adjustment. R69 provides adjustment for the maximum sweep width. Since the display-width control R68 also affects the sweep width, it should be adjusted beforehand. The control range of the centre frequency is adjusted using R113 at the lower and R79 at the upper end of the range.

Finally, the anode current limit of the valve R635 should be checked and adjusted if necessary. To accomplish this, the coarse and fine controls of the sweep width are turned completely counterclockwise; and then the coarse and fine controls of the centre frequency are turned completely clockwise. The voltage between the arm of R259 and the control grid of R635 is measured with a high-impedance voltmeter such as our Type URI (input impedance 10 M Ω). A bias voltage of 1.5 v should be measured, this value being adjusted with R259.

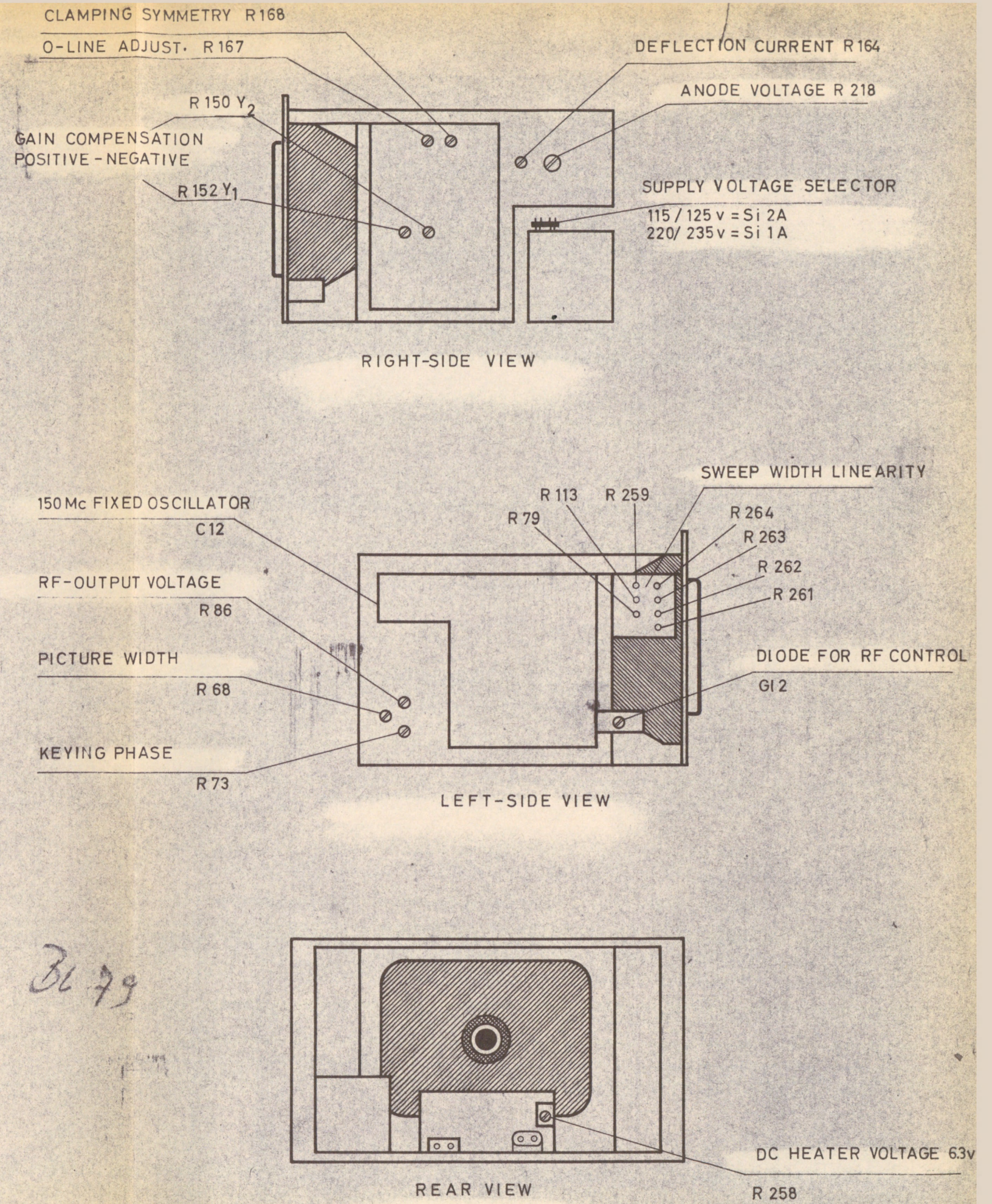


Fig. 23 LOCATION OF SCREWDRIVER ADJUSTMENTS

9. The Fundamentals of the Sweep Frequency Method with its Limitations

9.1 Introduction

There are several important things that must be taken into account in regard to transient response if the frequency response of any four-terminal network is measured not at fixed frequencies, but with a steadily changing frequency sweeping through the desired frequency range.

The simplest example for explanation is the response of a resonant circuit connected in the anode circuit of a pentode. If this resonant circuit is suddenly excited at its resonance frequency f_0 , the voltage across the circuit rises exponentially and reaches 100% of its final value after a definite time. The length of time taken to reach its final value is dependent upon the Q of the circuit and therefore its bandwidth. The greater the Q , the slower is the voltage rise across the circuit. Fig. 24 shows the response rise of such a resonant circuit.

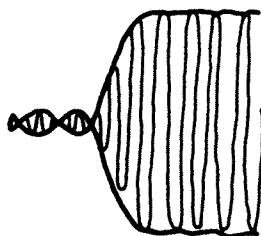


Fig. 24

The transient response time τ of a resonant circuit is calculated from

$$\tau = \frac{1}{B} \quad (\text{sec}) \quad (1)$$

where B is the 3-db bandwidth of the circuit. After the time τ , the voltage amplitude across the circuit has risen to over 95% of its final value (Fig. 25).

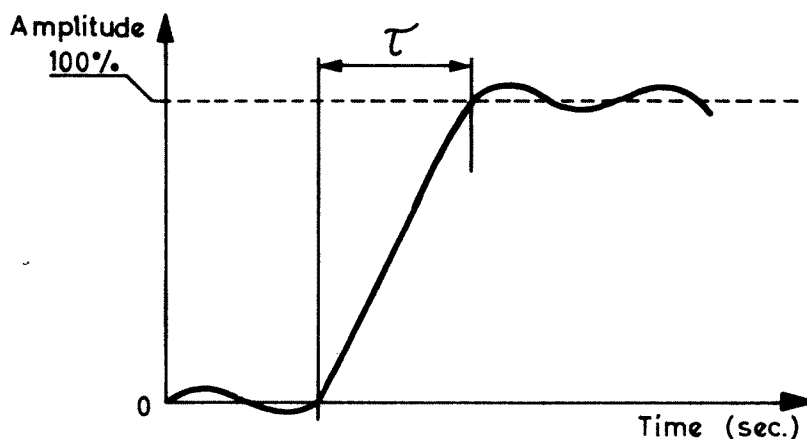


Fig. 25

If we want to measure the voltage amplitude of the resonant circuit without appreciable error, we must allow a time of at least τ so that the circuit can reach its full amplitude.

Now if we measure the same resonant circuit with a continuously changing frequency, the exciting frequency dwells only a short time in the bandwidth of the resonant circuit depending upon the sweep width and sweep time. This "dwell time" T_v must logically be at least equal to the time constant τ so that the resonant circuit may reach its full voltage amplitude.

$$T_v \geq \tau \quad (\text{sec}) \quad (2)$$

With periodic frequency sweeping, the ratio between the sweep width F and the bandwidth of the test item B is equal to the ratio between the sweep time T and the dwell time T_v . We may write

$$\frac{F}{B} = \frac{T}{T_v} \quad (3)$$

Substituting $T_v = \tau$ and $\tau = 1/B$ (equation 1) in equation 3, we obtain the important relationship

$$B = \sqrt{\frac{F}{T}} \quad (\text{cps}) \quad (4)$$

B = 3-db bandwidth of the resonant circuit

F = sweep width

T = sweep time

Using these relationships, the resulting error is less than 5% only in the case of simple single resonant circuits.

If the test item is a bandpass filter with a bandwidth B , the transient response τ is the same as for a single resonant circuit as described by

$$\tau = \frac{1}{B} \quad ((1))$$

If we use the relationship (4) as a basis for measurement, it is true that the amplitude of the transient response will reach over 95% of its maximum value, but the response curve would have an appearance just as if a single resonant circuit were being measured (Fig. 26).

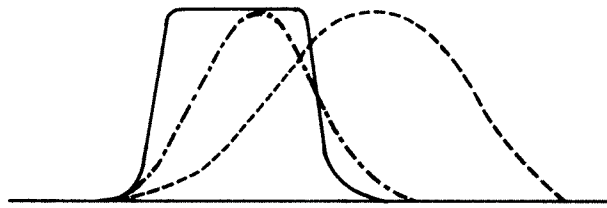


Fig. 26

The steep slopes of the bandpass curve are not resolved. Since we want to resolve the response curve of a test item as highly as possible, the dwell time T_v must be so dimensioned that it is sufficiently long for the sharpest amplitude changes (Fig. 27).

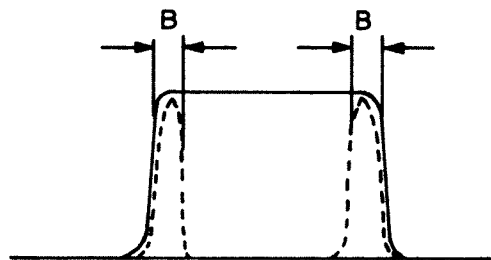


Fig. 27

If we think of the steepest slope as being one of the two slopes of a symmetrical response curve of a single-tuned circuit, the sweep rate F/T must be chosen to correspond with the bandwidth B' of this single-tuned circuit. We therefore obtain

$$B' = \sqrt{\frac{F}{T}} \quad (\text{cps}) \quad (5)$$

9.2 Sine-wave Frequency Sweep

The above analysis is made on the assumption that the sweep frequency varies strictly linearly with time (constant sweep rate). Many sweep generators are swept with a sine-wave voltage obtained from the AC supply, for instance. In this case, the sweep rate varies throughout the sweep cycle (Fig. 28).

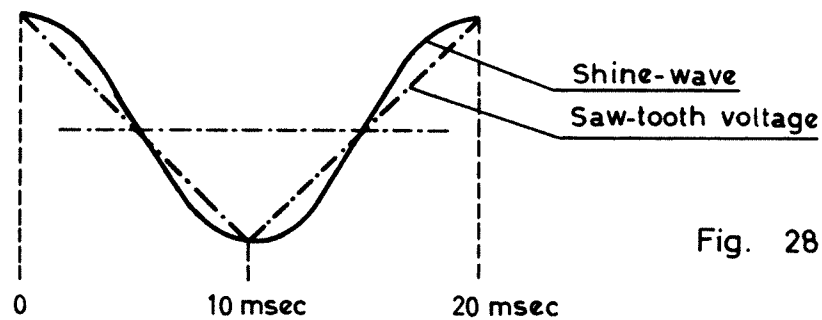


Fig. 28

We are interested in the fastest frequency change in the sine-wave cycle. The fastest change occurs as the voltage cycle passes through zero and has a value $\pi/2 = 1.57$ times greater than a saw-tooth voltage having a period equal to a half sine-wave period. For sine-wave sweeps, the following equation should be used in place of equation (4):

$$B = \sqrt{\frac{1.57 \cdot F}{T}} \quad (6)$$

We must always keep in mind that the resolution of the displayed response curve corresponding to equation (6) is only true at the centre of the display screen. The resolution is greater at the edges of the screen. The points A and A₁ in Fig. 25 have the same resolution as would be given by a linear saw-tooth sweep (Fig. 29).

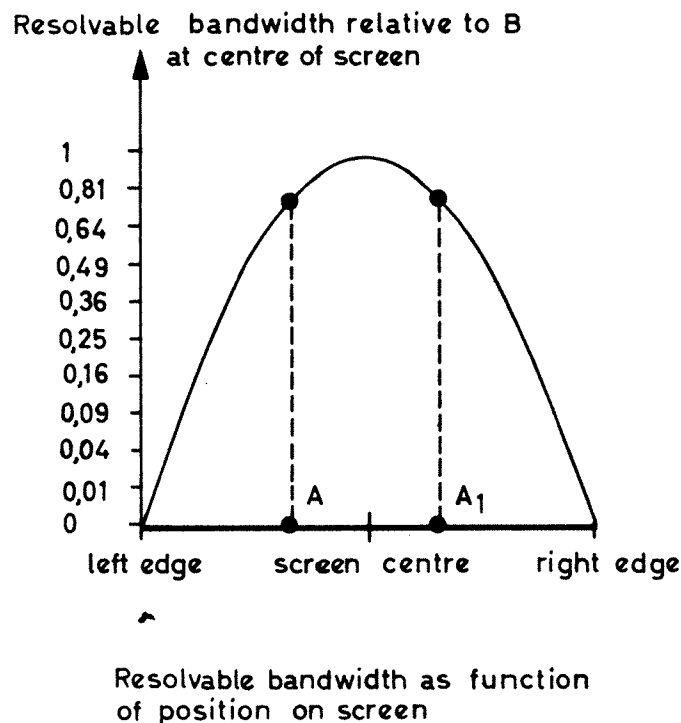


Fig. 29

By varying the centre frequency, the displayed curve can be moved to the left and to the right of the screen. If in doing this a change in resolution is observed, this indication can be used to test the adequacy of the necessary dwell time.

With the aid of the chart in Fig. 30 it is possible to determine a resolution factor for all values of sweep widths and sweep times that are normally encountered. Here, the resolution factor ρ is defined as the ratio of the smallest bandwidth having a sufficient dwell time as calculated in equation (4) to the entire sweep width, the sweep time being a parameter. This relationship may be written as

$$\rho = \frac{B}{F} \quad T = \text{parameter}$$

From the chart, we can see that the smaller the sweep width, the larger the resolution factor becomes (constant sweep time). The higher the resolution factor, the worse is the actual resolution since more and more of the displayed sweep is used in the transient response of the test item.

Let us take a special example of an extreme case. Suppose we have a steep-sloped bandpass filter that is to be measured with a sweep width and sweep time such that the filter bandwidth is just equal to the value B , i.e. $\rho = 100\%$. Instead of seeing a straight-line response curve displaced from the 0-reference line, we would see an exponential curve rising to its maximum amplitude to the right of the display screen. The resolution of the actual response curve is therefore extremely poor.

The chart of Fig. 30 may be used to help provide more clarification. Suppose we have a sweep time T of 10 msec and a sweep width F of 100 Mc, it is possible to resolve a least bandwidth B of 100 kc or 0.1% of the sweep width. If the sweep width F is decreased to 100 kc with the same sweep time T , a least bandwidth B of 3.16 kc can be resolved or 3% of the sweep width. If the sweep width is decreased even further to 1000 cps, the least bandwidth is only 316 cps or roughly 30% of the sweep width, i.e. 30% of the sweep width is used in the transient response of the test item. If we wish to resolve or provide sufficient dwell time for 1% of the sweep width, it is necessary to raise the sweep time T from 10^{-2} sec up to 10 sec when using a 1000 cps sweep width.

We should recognize the following points:

Sweep-frequency measuring equipment is especially suited for broadband measurements. The high sweep times (around 10^{-2} sec) give a flicker-free oscilloscope display. When using sweep widths greater than 300 kc, we may obtain in all cases a sufficient dwell time for bandwidths less than 1% of the sweep width, or expressed as 1% resolution.

Since the optical resolution of the displayed patterns on oscilloscopes is limited, a 1% resolution of the sweep width seems to be all that is necessary or reasonable.

9.3 Detection and Indication of the Measured Values

We have considered up to now the effect of the automatic frequency sweep upon the response curves of test items. The circuits involved in bringing the measurement results to the display screen of the picture tube will now be considered. These circuits include the rectifier arrangements for measuring the RF voltages and the vertical-deflection amplifiers with their display sections. All of the sections must be able to follow the sharpest amplitude variations of the test item without distortion, i.e. the system must have a sufficient rise time. The upper frequency limit f_g to be used in dimensioning the rectifier time constants and the vertical-deflection amplifiers may be calculated from equation (4) for any given sweep width and sweep time.

$$f_g \approx \sqrt{\frac{F}{T}} \quad (7)$$

We should note that the time constants of the rectifiers and the bandwidths of the deflection amplifiers have to be dimensioned with a limit frequency f_g that is equal to the least resolvable bandwidth for the highest sweep width that is to be used.

Example:

The sweep width F is 10 Mc; the sweep time is 10 msec. We are using a linear saw-tooth sweep. The least resolvable bandwidth B is calculated from equation (4)

$$B = \sqrt{\frac{10^7}{10^{-2}}} = 3.16 \cdot 10^4 = 31.6 \text{ (kc)}$$

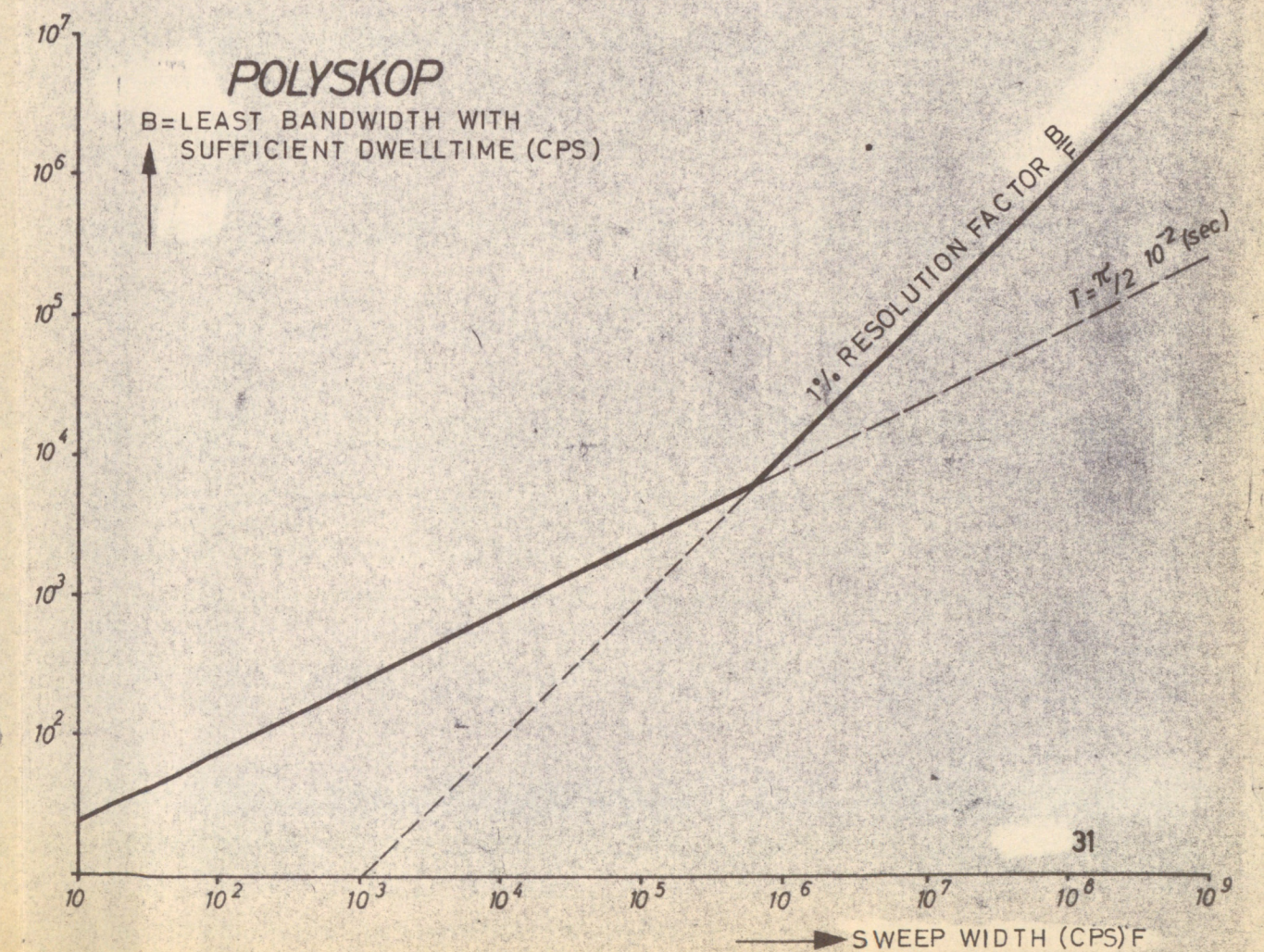
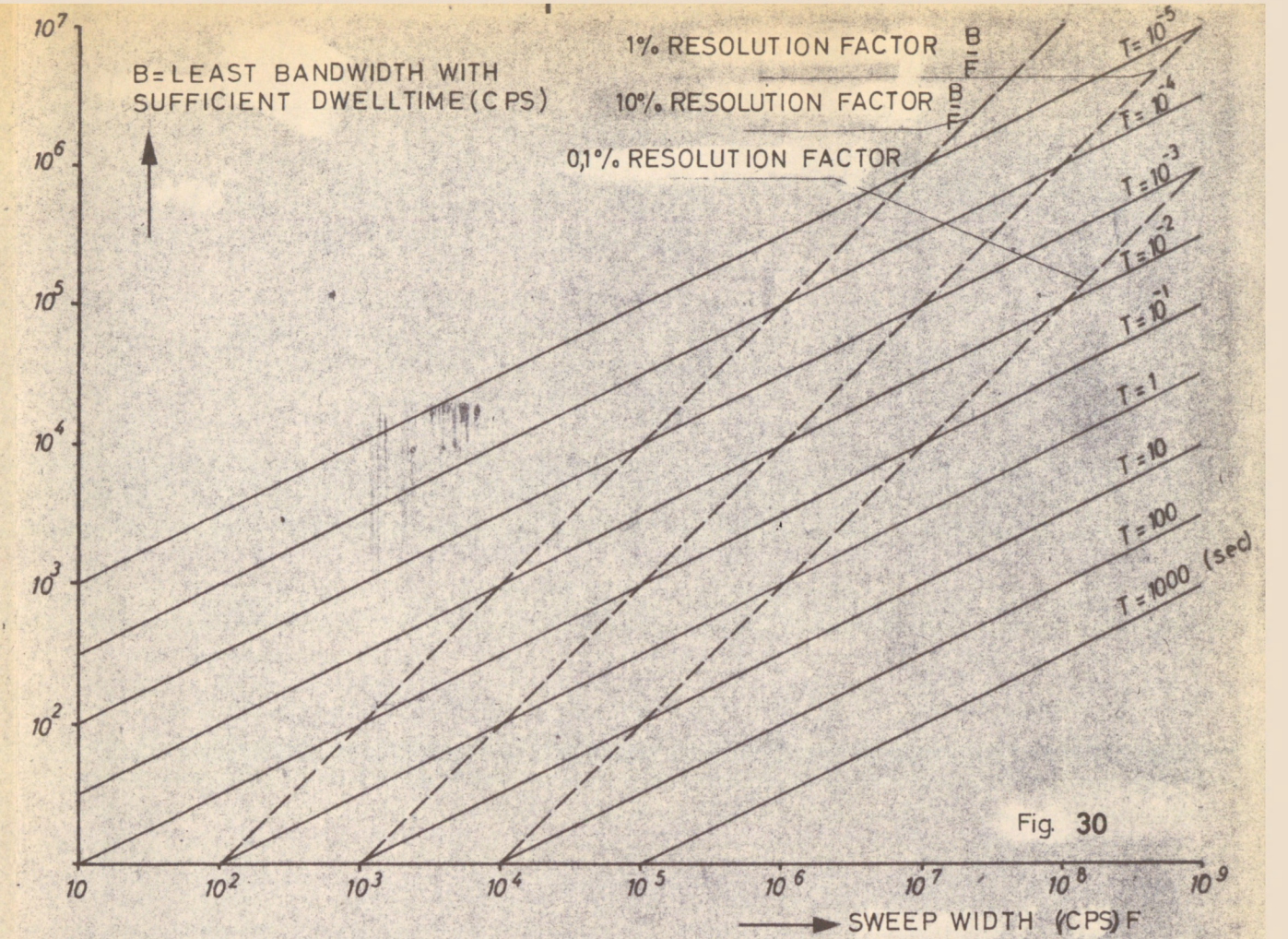
A resonant circuit with the bandwidth $B = 31.6$ kc will reach its full response amplitude. In order that the measured response voltage may be displayed without distortion, it is necessary that the diode detector and the vertical-deflection amplifier are able to handle a frequency as high as 31.6 kc.

9.4 Diode Detectors and Vertical-Deflection Amplifiers with Inadequate Bandwidths

In the above example in paragraph 9.3, the resolution would be very high using a vertical deflection system capable of handling 31.6 kc since the resolution factor is 0.316%. The oscilloscope display can only be optically evaluated to about 1% of its displayed width (sweep width) so that a resolution factor of 0.316% is not necessary. Logically, it is not necessary to build a deflection system with such a short rise time corresponding to a bandwidth of 31.6 kc. The deflection system in the POLYSKOP has a rise time of about 0.1 msec which corresponds to a bandwidth of about 7 kc. This results in a resolution factor of 1% for a sweep time of 10 msec. This resolution factor, governed only by the deflection system, remains constant at 1% for sweep widths over 300 kc. Under 300 kc, the resolution factors vary according to the relationship expressed by equation (4). Sweep widths under 300 kc cannot be adjusted on the POLYSKOP, so that for all practical purposes the POLYSKOP has a constant resolution factor of 1%. Fig. 31 shows the bandwidth B as a function of sweep width. Below the bend, the slope of the curve is determined by the sweep time of a 50-cps sine wave. Above the bend, the slope is determined by the rise time of the deflection system which gives a constant 1% resolution factor.

9.5 Effect of an Excessive Sweep Rate upon the Measurements

If a resonant circuit with the bandwidth B is swept with a frequency at such a rate that the dwell time is shorter than its transient response time, two very important effects may be determined (references 1) in addition to the insufficient amplitude response.



- (1) The amplitude maximum occurs at a frequency different from that determined from a point by point measurement. The maximum-amplitude frequency obtained from the sweep method lies higher than it should be, if the sweep is made in the low-to-high frequency direction. The reverse is true for a high-to-low sweep. If both the forward and reverse sweep response curves are simultaneously displayed, two resonance curves appear beside one another (Fig. 32).

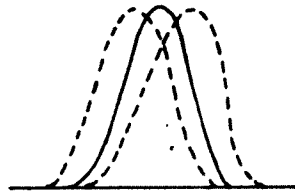


Fig. 32

- (2) The bandwidth of the test item is measured larger than it actually is. These two effects make themselves evident, even if the dwell time is sufficient for the test item, when the rise time of the deflection system is not adequate to give a faithful reproduction of the response curve.

When measurements are made on steep-sloped bandpass filters, the rise and fall of the response curves are displaced in frequency and appear flatter than they actually are (Fig. 33).

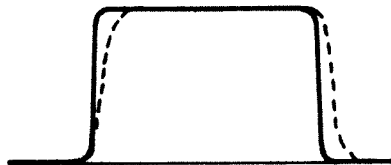


Fig. 33

9.6 Effect of Distortion in the Measuring Signal upon the Measurements

Signal generators used for frequency sweeping have distortion factors in the neighbourhood of a few per cent just like any other good signal generator of the usual construction. We want to investigate the effect of distortion upon the measuring accuracy.

In general the EMF of the signal generator is held constant with an automatic control circuit that is actuated from the peak value of the RF out-

put voltage. If the RF output has harmonic distortion, the RF peak values vary from the actual value of the fundamental frequency. For the most part, one may assume that the harmonic frequency components do not have sudden changes, but remain rather constant. As long as the bandwidth of the test item is relatively small, no noticeable measuring error will be caused by distortion in the measuring signal.

The situation is different when making measurements over very wide frequency ranges, especially in the video frequency range. Here the distortion of the measuring signal may lead to a display error that is up to twice as high as the signal generator distortion itself.

The easiest example for explanation is that of a low-pass filter. Suppose the filter has an upper limit frequency of 10 Mc. It is therefore not possible for harmonic frequencies over ~~5 Mc~~ to pass through to the output. A step in the response curve is noticeable at $1/2$ the limit frequency caused by the elimination of the second harmonic from the output. This step does not actually exist in the response curve of the test item. Another step is noticeable at $1/3$ the limit frequency due to the elimination of the third harmonic (Fig. 34).



Fig. 34

Distortion caused by the test item itself (overdriving or non-linear characteristics) shows up in the measurement results in the same manner.

We should note that distortion in the measuring signal or distortion caused by the test item shows up in the measured response curve as a measuring error, especially in wide-band measurements.

When making measurements on tuned trap circuits, the fundamental signal is suppressed, but not its harmonics. It must always be kept in mind that the distortion in the measuring signal causes a definite minimum indication no matter how high the actual signal suppression is (Fig. 35).

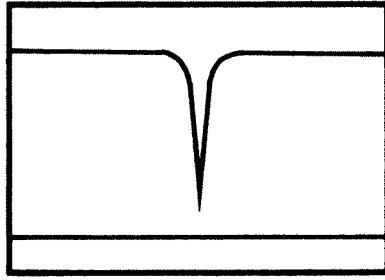


Fig. 35

Such measuring errors can only be avoided when the voltage at the output of the test item is measured with a selective circuit so that the harmonics are not included in the measurements.

9.7 Behaviour of Diodes Measuring Signals containing Distortion

If an RF voltage of a few volts is applied to a diode rectifier arrangement, the rectification is linear and follows the peak value of the RF voltage. This is not the case with small RF voltages of a few millivolts. The diodes are therefore driven on the curved portion of their characteristic curves; the rectification efficiency is lessened and the output voltage is no longer proportional to the peak values, but rather the effective values of the RF voltage. The sweep signal generator output voltage is controlled from a diode circuit operating at a sufficient voltage level to provide a linear peak rectification. Because of the pass-band attenuation and the attenuation in the test item, the diode probe rectifier connected in the test item output may be driven by a very low voltage where linear detection does not prevail. The difference in operating levels of the detector diodes causes measuring errors, especially when making measurements on low-pass filters using a measuring signal that contains distortion.

When measuring a low-pass filter with a measuring signal containing distortion, the rectifier arrangements give different results when the filter is driven with various input levels. This is especially true for test items having high pass-band attenuations.

10. Photographing the Display on the POLYSKOP

If it is desired to photograph the test patterns on the picture screen, any good camera is suitable. A photograph can be made without the use of a tripod by using the following:

Film sensitivity . . . 23⁰ DIN or ASA 200
Exposure time 1/25 sec
Lens opening f/3.5

Single-lens reflex cameras are especially suited for this purpose because they are free from parallax errors.

When setting up the POLYSKOP, one should take care that no direct reflections from the room lighting are to be seen in the picture screen. It is better to darken the room, but it is not absolutely necessary. The person operating the camera should not wear white clothing such as a laboratory smock since the image of the person will also be included in the photograph.

The brightness control of the POLYSKOP should only be advanced so far that a sharp display pattern still exists. Using full beam intensity at the expense of sharpness, the exposure time may be reduced to 1/50 sec.

If the display patterns are to be photographed often, we recommend that a lens attachment be procured that allows the full screen to be photographed from a distance of about 60 cm.

The Camera Adapter BN 42442 suitable for Polaroid-Land cameras model 110 A with a lens attachment No. 2 or for 35-mm mirror reflex cameras, e.g. for Exakta-Varex, can be supplied for photographing the displayed patterns.

11. References

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12. Table of Replaceable Parts

Ref. No.	Designation	Ratings	R&S Stock No.
BA1	Stabilizer, cell		BAS 11001
BA2	Stabilizer, cell		BAS 11001
C1	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C2	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C3	Capacitor, feed-through, paper	10,000 pf/300 v	CPD 10 000/300
C4	Capacitor, paper	10,000 pf/250 v	CPM 10 000/250
C5	Capacitor, paper	10,000 pf/250 v	CPM 10 000/250
C6	Capacitor, feed-through, paper	10,000 pf/300 v	CPD 10 000/300
C7	Capacitor, paper	10,000 pf/250 v	CPM 10 000/250
C8	Capacitor, paper	10,000 pf/250 v	CPM 10 000/250
C9	Capacitor, paper	10,000 pf/250 v	CPM 10 000/250
C10	Capacitor, feed-through, paper	10,000 pf/300 v	CPD 10 000/300
C11	Capacitor, ceramic	22 pf	CCG 68/22
C12	Trimmer, air	4 to 29 pf	CV 8125
C13	Capacitor, ceramic	22 pf	CCG 68/22
C15	Capacitor, ceramic	100 pf	CCH 68/100
C16	Capacitor, ceramic	330 pf	CCG 94/330
C17	Capacitor, ceramic	2200 pf	CCG 94/2200
C18	Trimmer, tubular, ceramic	0.5 to 3 pf	CV 7202
C19	Capacitor, ceramic	8 pf	CCG 41/8
C20	Trimmer, tubular, ceramic	0.5 to 3 pf	CV 7202
C21	Trimmer, tubular, ceramic	0.5 to 3 pf	CV 7202

Ref. No.	Designation	Ratings	R&S Stock No.
C22	Trimmer, tubular, ceramic	0.5 to 3 pf	CV 7202
C23	Trimmer, tubular, ceramic	0.5 to 3 pf	CV 7202
C24	Trimmer, tubular, ceramic	0.5 to 3 pf	CV 7202
C25	Capacitor, feed-through, paper	10,000 pf/300 v	CPD 10 000/300
C26	Trimmer, tubular, ceramic	1 to 11 pf	CV 7210
C27	Capacitor, ceramic	27 pf	CCH 31/27
C28	Trimmer, tubular, ceramic	1 to 11 pf	CV 7210
C29	Capacitor, ceramic	27 pf	CCH 31/27
C30	Trimmer, tubular, ceramic	1 to 11 pf	CV 7210
C31	Capacitor, ceramic	27 pf	CCH 31/27
C32	Trimmer, tubular, ceramic	1 to 11 pf	CV 7210
C33	Capacitor, ceramic	27 pf	CCH 31/27
C34	Capacitor, paper	10,000 pf/250 v	CPK 10 000/250
C35	Trimmer, tubular, ceramic	1 to 11 pf	CV 7210
C36	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C37	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C38	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C39	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C40	Capacitor, ceramic	2 pf	CCG 11/2
C41	Capacitor, ceramic	8 pf	CCG 41/8
C42	Capacitor, ceramic	22 pf	CCG 68/22
C43	Capacitor, ceramic	56 pf	CCH 31/56
C44	Capacitor, ceramic	10 pf	CCG 41/10
C45	Capacitor, ceramic	10 pf	CCG 41/10

Ref. No.	Designation	Ratings	R&S Stock No.
C46	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C47	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C48	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C49	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C50	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C51	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C52	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C53	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C54	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C55	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C56	Capacitor, bypass		E 415 - 6.3
C57	Capacitor, MP	0.5 μ f/2000 v	CMR 0,5/2000/2
C58	Capacitor, MP	0.5 μ f/3200 v	CMR 0,5/3200
C59	Capacitor, electrolytic	50 + 50 μ f/350 v	CEG 21/50 + 50/350
C60	Capacitor, electrolytic	50 + 50 μ f/350 v	CEG 21/50 + 50/350
C61	Capacitor, electrolytic	50 + 50 μ f/350 v	CEG 21/50 + 50/350
C62	Capacitor, electrolytic	50 + 50 μ f/350 v	CEG 21/50 + 50/350
C63	Capacitor, MP	2 μ f/500 v	CMR 2/500
C64	Capacitor, MP	2 μ f/500 v	CMR 2/500
C65	Capacitor, paper	100,000 pf/250 v	CPK 100 000/250
C66	Capacitor, paper	10,000 pf/250 v	CPK 10 000/250

Ref. No.	Designation	Ratings	R&S Stock No.
C67	Capacitor, electrolytic	16 + 16 μ f/350 v	CEG 21/16 + 16/350
C68	Capacitor, electrolytic	16 + 16 μ f/350 v	CEG 21/16 + 16/350
C69	Capacitor, paper	100,000 pf/400 v	CPK 100 000/400
C71	Capacitor, MP	16 μ f/250 v	CMR 16/250
C72	Capacitor, feed-through, paper	10,000 pf/300 v	CPD 10 000/300
C73	Capacitor, paper	10,000 pf/250 v	CPM 10 000/250
C74	Capacitor, feed-through, paper	10,000 pf/300 v	CPD 10 000/300
C75	Capacitor, bypass		incl. in 4245-10.1
C76	Capacitor		incl. in 4245-7.1
C77	Capacitor, MP	1 μ f/250 v	CMR 1/250/2
C78	Capacitor, MP	1 μ f/160 v	CMR 1/160/2
C79	Capacitor, synth. foil	2500 pf/250 v	CKS 2500/250
C80	Capacitor, MP	1 μ f/160 v	CMR 1/160/2
C81	Capacitor, electrolytic	10 μ f/15 v	CED 21/10/15
C82	Capacitor, synth. foil	1000 pf/1000 v	CKS 1000/1000
C83	Capacitor, MP	1 μ f/250 v	CMR 1/250/1
C84	Capacitor, MP	1 μ f/250 v	CMR 1/250/1
C85	Capacitor, ceramic	220 pf	CCG 68/220
C86	Capacitor, MP	1 μ f/250 v	CMR 1/250/2
C87	Capacitor, electrolytic	100 + 100 μ f/350 v	CEG 21/100 + 100/35
C88	Capacitor, MP	1 μ f/160 v	CMR 1/160/2
C89	Capacitor, synth. foil	2500 pf/250 v	CKS 2500/250
C90	Capacitor, MP	1 μ f/160 v	CMR 1/160/2
C91	Capacitor, ceramic	27 pf	CCG 68/27
C92	Capacitor, feed-through, ceramic	10,000 pf/300 v	CPD 10 000/300

Ref. No.	Designation	Ratings	R&S Stock No.
C93	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C94	Capacitor, paper	5000 pf/400 v	CPK 5000/400
C95	Capacitor, ceramic	100 pf	CCH 68/100
C96	Capacitor, ceramic	100 pf	CCH 68/100
C97	Capacitor, ceramic	220 pf	CCH 68/220
C98	Capacitor, ceramic	220 pf	CCH 68/220
C99	Capacitor, ceramic	100 pf	CCH 68/100
C100	Capacitor, electrolytic	4 μ f/350 v	CED 21/4/350
C101	Capacitor, electrolytic	100 μ f/100 v	CED 21/100/100
C103	Capacitor, ceramic	27 pf	CCH 68/27
C104	Capacitor, ceramic	33 pf	CCH 68/33
C105	Capacitor, feed-through, paper	50,000 pf/300 v	CPD 50 000/300
C106	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C107	Capacitor, feed-through, ceramic	5000 pf/500 v	CFR 1/5000/500
C108	Capacitor, ceramic	56 pf	CCH 31/56
C109	Capacitor, ceramic	100 pf	CCH 68/100
C110	Capacitor, ceramic	10 pf	CCH 41/10
C111	Capacitor, synth. foil	500 pf/500 v	CKS 500/500
C112	Capacitor, ceramic	27 pf	CCG 68/27
C113	Capacitor, ceramic	56 pf	CCH 31/56
C114	Capacitor, ceramic	22 pf	CCH 31/22
C115	Capacitor, ceramic	220 pf	CCH 68/220
C116	Capacitor, paper	50,000 pf/250 v	CPM 50 000/250
C117	Capacitor, feed-through, paper	50,000 pf/300 v	CPD 50 000/300

Ref. No.	Designation	Ratings	R&S Stock No.
C118	Capacitor, paper	50,000 pf/250 v	CPM 50 000/250
C119	Capacitor, feed-through, paper	50,000 pf/300 v	CPD 50 000/300
C120	Capacitor, bypass	2500 pf/350 v	CBR 1/2500/350
C121	Capacitor, feed-through, paper	50,000 pf/300 v	CPD 50 000/300
C122	Capacitor, bypass	2500 pf/350 v	CBR 1/2500/350
C123	Capacitor, feed-through, paper	50,000 pf/300 v	CPD 50 000/300
C124	Capacitor, synth. foil	1000 pf/500 v	CKS 1000/500
C125	Capacitor, ceramic	10 pf	CCG 41/10
C126	Capacitor, paper	100,000 pf/250 v	CPK 100 000/250
C127	Capacitor, ceramic	2 pf	CCG 11/2
C128	Capacitor, ceramic	2 pf	CCG 68/2
C129	Capacitor, paper	1000 pf/1000 v	CPK 1000/1000
C130	Capacitor, synth. foil	10,000 pf/250 v	CKS 10 000/250
C131	Capacitor, ceramic	10 pf	CCG 68/10
C132	Capacitor, ceramic	27 pf	CCG 68/27
C133	Capacitor, ceramic	100 pf	CCH 68/100
C134	Capacitor, ceramic	100 pf	CCH 68/100
C135	Capacitor, electrolytic	2500 μ f/35 v	CEE 21/2500/35
C136	Capacitor, synth. foil	2000 pf/125 v	CKD 2/2000/125
C137	Capacitor, ceramic	0.5 pf	CCG 11/0,5
C138	Capacitor, ceramic	33 pf	CCH 68/33
C139	Capacitor, ceramic	330 pf	CCH 68/330
C140	Capacitor, ceramic	330 pf	CCH 68/330
G11	Diode, germanium		2 x GK 2501
G12	Diode, germanium		E 4244 - 36
G13	Rectifier, HT	2000 v/2.5 ma	GNE 27/2000/2,5 D

Ref. No.	Designation	Ratings	R&S Stock No.
G14	Rectifier, power	4 x 360 v/100 ma	2 x GN 19/720/100 I
G15	Rectifier, power	2 x 360 v/100 ma	GN 19/720/100 M
G16	Rectifier, power	250 v/40 ma	GNE 14/250/40 M
G17	Diode, silicon		GK/OA 202
G18	Diode, germanium		E 4244 - 36
G19	Diode, germanium		E 4244 - 36
G110	Diode, germanium		GK 2281
G111	Diode, germanium		GK 2281
G112	Diode, germanium		E 4244 - 36
G113	Rectifier, power	30 v/2000 ma	GNB 11/30/2000 B
G114	Diode, Zener		GK/OA 126/4
G115	Rectifier, HT	2000 v/2.5 ma	GNE 27/2000/2,5 D
L1	Coil		BV 105 745
L2	Coil		BV 105 746
L3	Coil		BV 105 747
L4	Coil		BV 105 748
L5	Coil		BV 105 748
L6	Coil		BV 105 748
L7	Coil		BV 105 748
L8	Coil		
L9	Coil		
L10	Coil		
L11	Coil		BV 105 749
L12	Coil		
L13	Coil		
L14	Coil		

Ref. No.	Designation	Ratings	R&S Stock No.
L15	Choke, RF		DUF 311/20
L16	Choke, RF		DUF 311/20
L17	Coil		BV 100 743
L18	Coil, oscillator		BV 105 750
L19	Coil		BV 105 750
L20	Coil, oscillator		BV 104 701
L21	Coil		BV 104 701
L22	Coil		BV 100 743
L23	Coil		BV 100 743
L24	Coil, oscillator		BV 112 317
L25	Coil, oscillator		BV 112 318
L26	Coil		BV 100 743
L27	Choke, RF		DUF 311/20
L28	Choke, RF		DUF 311/20
L29	Choke, filter		DB 125/2
L30	Choke, filter		DB 125/2
L31	Coil, horiz. defl.		E 415 - 50
L32	Coil, vert. defl.		E 415 - 50
L33	Coil, focusing		BV 105 970
L34	Coil		BV 104 709
L35	Coil		BV 104 706
L36	Coil		BV 104 704
L37	Coil		BV 104 708
L38	Coil		BV 104 707
L39	Choke, RF		DUF 311/20
L40	Choke, RF		DUF 311/20
L41	Choke, RF		DUF 311/20

Ref. No.	Designation	Ratings	R&S Stock No.
L42	Choke		BV 112 350
L43	Choke		BV 112 350
L44	Ferrit tube		MFR 04131/3
Mo1	Motor, blower		ZAM 17 001 with fans ZV 220/10-1
M1	Ion-trap magnet		4244 - 8.12
Q1	Crystal	10 Mc	QA 206300/10 000
Q2	Crystal	1 Mc	QA 206300/1000
R1	Resistor, depos. carbon	5 k Ω /0.5 w	WF 5 k/0,5
R2	Resistor, depos. carbon	50 k Ω /0.1 w	WFA 50 k/0,1
R3	Resistor, depos. carbon	500 Ω /0.25 w	WF 500/0,25
R4	Resistor, depos. carbon	50 k Ω /0.1 w	WFA 50 k/0,1
R5	Resistor, depos. carbon	10 Ω /0.05 w	WFA 10/0,05
R6	Resistor, depos. carbon	100 Ω /0.25 w	WF 100/0,25
R7	Resistor, depos. carbon	50 k Ω /0.25 w	WF 50 k/0,25
R8	Resistor, depos. carbon	600 Ω /0.25 w	WF 600/0,25
R9	Resistor, depos. carbon	30 Ω /0.25 w	WF 30/0,25
R10	Resistor, depos. carbon	250 Ω /0.25 w	WF 250/0,25
R11	Resistor, depos. carbon	10 Ω /0.05 w	WFA 10/0,05
R12	Resistor, depos. carbon	600 Ω /0.25 w	WF 600/0,25
R13	Resistor, depos. carbon	10 k Ω /0.25 w	WF 10/k/0,25
R14	Resistor, depos. carbon	30 Ω /0.25 w	WF 30/0,25
R15	Resistor, depos. carbon	1.25 k Ω /0.5 w	WF 1,25 k/0,5
R16	Resistor, depos. carbon	500 Ω /0.25 w	WF 500/0,25

Ref. No.	Designation	Ratings	R&S Stock No.
R17	Resistor, depos. carbon	200 k Ω /0.5 w	WF 200 k/0,25
R18	Resistor, depos. carbon	16 k Ω /0.25 w	WF 16 k/0,25
R19	Resistor, depos. carbon	250 k Ω /0.5 w	WF 250 k/0,5
R20	Resistor, depos. carbon	10 Ω /0.05 w	WFA 10/0,05
R21	Resistor, depos. carbon	600 Ω /0.25 w	WF 600/0,25
R22	Resistor, depos. carbon	10 Ω /0.05 w	WFA 10/0,05
R23	Resistor, depos. carbon	600 Ω /0.025 w	WF 600/0,25
R24	Resistor, depos. carbon	10 Ω /0.05 w	WFA 10/0,05
R25	Resistor, depos. carbon	600 Ω /0.25 w	WF 600/0,25
R26	Resistor, depos. carbon	10 Ω /0.05 w	WFA 10/0,05
R27	Resistor, depos. carbon	600 Ω /0.25 w	WF 600/0,25
R28	Resistor, depos. carbon	30 Ω /0.25 w	WF 30/0,25
R29	Resistor, depos. carbon	30 Ω /0.25 w	WF 30/0,25
R30	Resistor, depos. carbon	30 Ω /0.25 w	WF 30/0,25
R31	Resistor, depos. carbon	30 Ω /0.25 w	WF 30/0,25
R32	Resistor, depos. carbon	200 Ω /1 w	WF 200/1
R33	Resistor, depos. carbon	60 Ω /0.25 w	WF 60/0,25
R34	Resistor, depos. carbon	60 Ω /0.25 w	WF 60/0,25
R35	Resistor, depos. carbon	5 Ω /0.05 w	WF 5/0,05
R36	Resistor, depos. carbon	5 Ω /0.05 w	WF 5/0,05
R37	Resistor, depos. carbon	5 Ω /0.05 w	WF 5/0,05
R38	Resistor, depos. carbon	5 Ω /0.05 w	WF 5/0,05
R39	Resistor, depos. carbon	160 Ω /0.05 w	WFA 160/0,05
R40	Resistor, depos. carbon	160 Ω /0.05 w	WFA 160/0,05
R41	Resistor, depos. carbon	10 k Ω /0.25 w	WF 10 k/0,25
R42	Resistor, depos. carbon	5 k Ω /0.5 w	WFO 5 k/0,5

Ref. No.	Designation	Ratings	R&S Stock No.
R43	Resistor, depos. carbon	5 k Ω /0.5 w	WFO 5 k/0,5
R44	Resistor, depos. carbon	50 k Ω /0.1 w	WFA 50 k/0,1
R45	Resistor, depos. carbon	50 k Ω /0.1 w	WFA 50 k/0,1
R46	Resistor, depos. carbon	125 Ω /0.25 w	WF 125/0,25
R47	Resistor, depos. carbon	2.5 k Ω /0.5 w	WFO 2,5 k/0,5
R48	Resistor, depos. carbon	50 k Ω /0.1 w	WFA 50 k/0,1
R49	Resistor, depos. carbon	12.5 k Ω /0.1 w	WFA 12,5 k/0,1
R50	Resistor, depos. carbon	2 k Ω /0.5 w	WFO 2 k/0,5
R51	Resistor, depos. carbon	200 Ω /0.25 w	WF 200/0,25
R52	Resistor, depos. carbon	60 Ω $\pm$ 0.5%/1 w	WFK 611/60/0,5/1
R53	Resistor, depos. carbon	25 k Ω /0.25 w	WF 25 k/0,25
R54	Resistor, depos. carbon	1 k Ω /0.1 w	WFA 1 k/0,1
R55	Resistor, depos. carbon	500 Ω /0.25 w	WF 500/0,25
R56	Resistor, depos. carbon	500 Ω /0.25 w	WF 500/0,25
R57	Resistor, depos. carbon	500 Ω /0.25 w	WF 500/0,25
R58	Resistor, depos. carbon	100 Ω /0.25 w	WF 100/0,25
R61	Resistor, depos. carbon	500 Ω /0.25 w	WF 500/0,25
R63	Resistor, depos. carbon	50 k Ω /0.5 w	WF 50 k/0,5
R64	Resistor, depos. carbon	10 k Ω /0.5 w	WF 10 k/0,5
R65	Resistor, depos. carbon	6 M Ω /0.5 w	WF 6 M/0,5
R66	Resistor, depos. carbon	6 M Ω /0.5 w	WF 6 M/0,5
R67	Resistor, wire-wound	3 k Ω /12 w	WV 12/3 k
R68	Resistor, wire-wound, variable	100 Ω lin.	WR 4/100

Ref. No.	Designation	Ratings	R&S Stock No.
R69	Resistor, wire-wound variable	100 Ω lin.	WR 4/100
R70	Resistor, depos. carbon, variable	50 k Ω lin.	E 415 - 40.1/50 k
R71	Resistor, depos. carbon, variable	2.5 k Ω lin.	WS 7126/2,5 k
R72	Resistor, depos. carbon	8 k Ω /1 w	WF 8 k/1
R73	Resistor, depos. carbon, variable	10 k Ω lin.	WS 7122 F/10 k
R74	Resistor, depos. carbon	20 k Ω /0.5 w	WF 20 k/0,5
R75	Resistor, depos. carbon	200 k Ω /0.25 w	WF 200 k/0,25
R76	Resistor, depos. carbon	1 M Ω /0.25 w	WF 1 M/0,25
R77	Resistor, depos. carbon	1 k Ω /0.25 w	WF 1 k/0,25
R78	Resistor, depos. carbon	1 k Ω /0.1 w	WFA 1 k/0,1
R79	Resistor, depos. carbon, variable	500 k Ω lin.	WS 9122 F/500 k
R80	Resistor, depos. carbon	1 k Ω /0.1 w	WFA 1 k/0,1
R81	Resistor, depos. carbon	100 k Ω /0.5 w	WF 100 k/0,5
R82	Resistor, depos. carbon	1 k Ω /0.1 w	WFA 1 k/0,1
R83	Resistor, depos. carbon	500 k Ω /0.5 w	WF 500 k/0,5
R84	Resistor, depos. carbon	1 k Ω /0.1 w	WFA 1 k/0,1
R85	Resistor, depos. carbon	500 k Ω /0.5 w	WF 400 k/0,5
R86	Resistor, depos. carbon, variable	500 k Ω lin.	WS 7122 F/500 k
R87	Resistor, depos. carbon	10 k Ω /0.25 w	WF 10 k/0,25
R88	Resistor, depos. carbon	50 k Ω /0.25 w	WF 50 k/0,25
R89	Resistor, depos. carbon	500 Ω /0.25 w	WF 500/0,25
R90	Resistor, depos. carbon	500 Ω /0.25 w	WF 500/0,25
R91	Resistor, depos. carbon	500 Ω /0.25 w	WF 500/0,25

Ref. No.	Designation	Ratings	R&S Stock No.
R92	Resistor, depos. carbon	115 Ω $\pm 1\%$ /0.1 w	WFS 5/115/1/0,1
R93	Resistor, depos. carbon	115 Ω $\pm 1\%$ /0.1 w	WFS 5/115/1/0,1
R94	Resistor, depos. carbon	115 Ω $\pm 1\%$ /0.1 w	WFS 5/115/1/0,1
R95	Resistor, depos. carbon	115 Ω $\pm 1\%$ /0.1 w	WFS 5/115/1/0,1
R96	Resistor, depos. carbon	115 Ω $\pm 1\%$ /0.1 w	WFS 5/115/1/0,1
R97	Resistor, depos. carbon	115 Ω $\pm 1\%$ /0.1 w	WFS 5/115/1/0,1
R98	Resistor, depos. carbon	115 Ω $\pm 1\%$ /0.1 w	WFS 5/115/1/0,1
R99	Resistor, depos. carbon	115 Ω $\pm 1\%$ /0.1 w	WFS 5/115/1/0,1
R100	Resistor, depos. carbon	115 Ω $\pm 1\%$ /0.1 w	WFS 5/115/1/0,1
R101	Resistor, depos. carbon	115 Ω $\pm 1\%$ /0.1 w	WFS 5/115/1/0,1
R102	Resistor, depos. carbon	115 Ω $\pm 1\%$ /0.1 w	WFS 5/115/1/0,1
R103	Resistor, depos. carbon	115 Ω $\pm 1\%$ /0.1 w	WFS 5/115/1/0,1
R104	Resistor, depos. carbon	85.3 Ω $\pm 1\%$ /0.1 w	WFS 5/85,3/1/0,1
R105	Resistor, depos. carbon	85.3 Ω $\pm 1\%$ /0.1 w	WFS 5/85,3/1/0,1
R106	Resistor, depos. carbon	85.3 Ω $\pm 1\%$ /0.1 w	WFS 5/85,3/1/0,1
R107	Resistor, depos. carbon	85.3 Ω $\pm 1\%$ /0.1 w	WFS 5/85,3/1/0,1
R108	Resistor, depos. carbon	85.3 Ω $\pm 1\%$ /0.1 w	WFS 5/85,3/1/0,1
R109	Resistor, depos. carbon	85.3 Ω $\pm 1\%$ /0.1 w	WFS 5/85,3/1/0,1
R110	Resistor, depos. carbon	100 k Ω /0.25 w	WF 100 k/0,25
R111	Resistor, depos. carbon	1 k Ω /0.1 w	WFA 1 k/0,1
R113	Resistor, depos. carbon, variable	25 k Ω lin.	WS 9122 F/25 k
R114	Resistor, depos. carbon	30 k Ω /0.5 w	WF 30 k/0,5
R115	Resistor, depos. carbon	400 k Ω /0.25 w	WF 400 k/0,25
R116	Resistor, depos. carbon	500 Ω /0.25 w	WF 500/0,25
R117	Resistor, depos. carbon	200 k Ω /0.5 w	WF 200 k/0,5
R118	Resistor, depos. carbon	30 Ω /0.5 w	WF 30/0,5

Ref. No.	Designation	Ratings	R&S Stock No.
R119	Resistor, depos. carbon	100 k Ω /0.25 w	WFA 100 k/0,05
R120	Resistor, depos. carbon	60 Ω $\pm$ 0.5%/1 w	WFK 611/60/0,5/1
R121	Resistor, depos. carbon, variable	500 k Ω log.	WS 7226/500 k
R122	Resistor, depos. carbon	1 k Ω /0.1 w	WFA 1 k/0,1
R123	Resistor, depos. carbon	40 k Ω /0.5 w	WF 40 k/0,5
R124	Resistor, depos. carbon	200 k Ω /0.5 w	WF 200 k/0,5
R125	Resistor, depos. carbon	125 k Ω /0.5 w	WF 125 k/0,5
R126	Resistor, depos. carbon	1.25 M Ω /0.25 w	WF 1,25 M/0,25
R127	Resistor, depos. carbon	1 k Ω /0.25 w	WF 1 k/0,25
R128	Resistor, depos. carbon	20 M Ω /0.5 w	WF 20 M/0,5
R129	Resistor, depos. carbon	5 k Ω /0.25 w	WF 5 k/0,25
R130	Resistor, depos. carbon	50 k Ω /0.5 w	WF 50 k/0,5
R131	Resistor, depos. carbon	60 k Ω /0.5 w	WF 60 k/0,5
R132	Resistor, depos. carbon	250 k Ω /0.5 w	WF 250 k/0,5
R133	Resistor, depos. carbon	5 k Ω /0.5 w	WF 5 k/0,5
R134	Resistor, depos. carbon	20 k Ω /0.25 w	WF 20 k/0,25
R135	Resistor, depos. carbon	1.6 M Ω /0.25 w	WF 1,6 M/0,25
R136	Resistor, depos. carbon	1 k Ω /0.1 w	WFA 1 k/0,1
R137	Resistor, depos. carbon	2.5 M Ω /0.5 w	WF 2,5 M/0,5
R138	Resistor, depos. carbon	25 k Ω /0.5 w	WF 25 k/0,5
R139	Resistor, depos. carbon	4 k Ω /0.5 w	WF 4 k/0,5
R140	Resistor, depos. carbon	500 Ω /0.25 w	WF 500/0,25
R141	Resistor, wire-wound, variable	50 Ω lin.	WR 4/50
R142	Resistor, depos. carbon	40 k Ω /0.25 w	WF 40 k/0,25
R143	Resistor, depos. carbon	125 Ω /0.25 w	WF 125/0,25
R144	Resistor, depos. carbon	100 k Ω /0.25 w	WF 100 k/0,25

Ref. No.	Designation	Ratings	R&S Stock No.
R145	Resistor, depos. carbon	125 k Ω /0.5 w	WF 125 k/0,5
R146	Resistor, depos. carbon	200 k Ω /0.25 w	WF 200 k/0,25
R147	Resistor, depos. carbon	60 Ω /0.25 w	WF 60/0,25
R148	Resistor, depos. carbon	500 k Ω /0.25 w	WF 500 k/0,25
R149	Resistor, depos. carbon	1 k Ω /0.25 w	WF 1 k/0,25
R150	Resistor, depos. carbon, variable	10 k Ω lin.	WS 9122 F/10 k
R151	Resistor, depos. carbon	50 k Ω /0.1 w	WFA 50 k/0,1
R152	Resistor, depos. carbon, variable	10 k Ω lin.	WS 9122 F/10 k
R154	Resistor, depos. carbon	1 k Ω /0.1 w	WFA 1 k/0,1
R155	Resistor, depos. carbon	160 k Ω /0.5 w	WF 160 k/0,5
R156	Resistor, depos. carbon	30 k Ω /0.5 w	WF 30 k/0,5
R157	Resistor, depos. carbon	3 k Ω /0.25 w	WF 3 k/0,25
R158	Resistor, depos. carbon	600 k Ω /0.5 w	WF 600 k/0,5
R159	Resistor, depos. carbon	250 k Ω /0.5 w	WF 250 k/0,5
R160	Resistor, depos. carbon, variable	250 k Ω lin.	WS 7126/250 k
R161	Resistor, depos. carbon	1 k Ω /0.25 w	WF 1 k/0,25
R162	Resistor, depos. carbon	200 Ω /0.5 w	WF 200/0,5
R163	Resistor, depos. carbon	30 Ω /0.25 w	WF 30/0,25
R164	Resistor, wire-wound	10 k Ω /10 w	WR 10 F/10 k
R165	Resistor, depos. carbon	800 k Ω /0.25 w	WF 800 k/0,25
R166	Resistor, depos. carbon	250 k Ω /0.5 w	WF 250 k/0,5
R167	Resistor, depos. carbon, variable	50 k Ω lin.	WS 7122 F/50 k
R168	Resistor, depos. carbon, variable	50 k Ω lin.	WS 7122 F/50 k

Ref. No.	Designation	Ratings	R&S Stock No.
R169	Resistor, depos. carbon, variable	500 k Ω log.	WS 7226/500 k
R170	Resistor, depos. carbon	1 k Ω /0.1 w	WPA 1 k/0,1
R171	Resistor, depos. carbon	200 k Ω /0.5 w	WF 200 k/0,5
R172	Resistor, depos. carbon	125 k Ω /0.5 w	WF 125 k/0,5
R173	Resistor, depos. carbon	40 k Ω /0.5 w	WF 40 k/0,5
R174	Resistor, depos. carbon	1.25 M Ω /0.25 w	WF 1,25 M/0,25
R175	Resistor, depos. carbon	1 k Ω /0.25 w	WF 1 k/0,25
R176	Resistor, depos. carbon	20 M Ω /0.5 w	WF 20 M/0,5
R177	Resistor, depos. carbon	50 k Ω /0.5 w	WF 50 k/0,5
R178	Resistor, depos. carbon	60 k Ω /0.5 w	WF 60 k/0,5
R179	Resistor, depos. carbon	250 k Ω /0.5 w	WF 250 k/0,5
R180	Resistor, depos. carbon	5 k Ω /0.5 w	WF 5 k/0,5
R181	Resistor, depos. carbon	20 k Ω /0.25 w	WF 20 k/0,25
R182	Resistor, depos. carbon	1.6 M Ω /0.25 w	WF 1,6 M/0,25
R183	Resistor, depos. carbon	1 k Ω /0.1 w	WPA 1 k/0,1
R184	Resistor, depos. carbon	2.5 M Ω /0.5 w	WF 2,5 M/0,5
R185	Resistor, depos. carbon	25 Ω /0.25 w	WF 25/0,25
R186	Resistor, depos. carbon	4 k Ω /0.5 w	WF 4 k/0,5
R188	Resistor, depos. carbon	160 k Ω /0.5 w	WF 160 k/0,5
R190	Resistor, depos. carbon	40 k Ω /0.25 w	WF 40 k/0,25
R191	Resistor, depos. carbon	1 k Ω /0.25 w	WF 1 k/0,25
R192	Resistor, depos. carbon	10 k Ω /0.5 w	WF 10 k/0,5
R193	Resistor, depos. carbon	10 k Ω /0.5 w	WF 10 k/0,5
R194	Resistor, depos. carbon	500 k Ω /0.5 w	WF 500 k/0,5

Ref. No.	Designation	Ratings	R&S Stock No.
R195	Resistor, depos. carbon	1 k Ω /0.1 w	WFA 1 k/0,1
R196	Resistor, depos. carbon	1 k Ω /0.1 w	WFA 1 k/0,1
R197	Resistor, depos. carbon	800 k Ω /0.25 w	WF 800 k/0,25
R198	Resistor, depos. carbon	50 k Ω /0.1 w	WFA 50 k/0,1
R199	Resistor, depos. carbon	1 M Ω /0.25 w	WF 1 M/0,25
R200	Resistor, depos. carbon	1 M Ω /0.25 w	WF 1 M/0,25
R201	Resistor, depos. carbon	600 k Ω /0.25 w	WF 600 k/0,25
R202	Resistor, depos. carbon	50 k Ω /0.5 w	WF 50 k/0,5
R203	Resistor, depos. carbon	50 k Ω /0.5 w	WF 50 k/0,5
R204	Resistor, depos. carbon	600 k Ω /0.25 w	WF 600 k/0,25
R205	Resistor, depos. carbon	400 k Ω /0.25 w	WF 400 k/0,25
R206	Resistor, depos. carbon	1.25 M Ω /0.25 w	WF 1,25 M/0,25
R207	Resistor, depos. carbon	500 k Ω /0.25 w	WF 500 k/0,25
R208	Resistor, depos. carbon	10 k Ω /0.5 w	WF 10 k/0,5
R209	Resistor, depos. carbon	50 k Ω /0.5 w	WF 50 k/0,5
R210	Resistor, depos. carbon	500 k Ω /0.25 w	WF 500 k/0,25
R211	Resistor, depos. carbon	500 k Ω /0.5 w	WF 500 k/0,5
R212	Resistor, depos. carbon	30 Ω /0.25 w	WF 30/0,25
R213	Resistor, depos. carbon	30 Ω /0.25 w	WF 30/0,25
R214	Resistor, depos. carbon	1 k Ω /0.1 w	WFA 1 k/0,1
R215	Resistor, depos. carbon	1 k Ω /0.1 w	WFA 1 k/0,1
R216	Resistor, depos. carbon	30 k Ω /0.5 w	WF 30 k/0,5
R217	Resistor, depos. carbon	100 k Ω /0.5 w	WF 100 k/0,5
R218	Resistor, depos. carbon, variable	25 k Ω lin.	WS 7122 F/25 k
R219	Resistor, depos. carbon	50 k Ω /0.5 w	WF 50 k/0,5
R220	Resistor, depos. carbon	12.5 k Ω /0.5 w	WF 12,5 k/0,5

Ref. No.	Designation	Ratings	R&S Stock No.
R221	Resistor, depos. carbon	50 k Ω /0.5 w	WF 50 k/0,5
R222	Resistor, wire-wound	10 k Ω /10 w	WR 10/10 k
R223	Resistor, depos. carbon	200 k Ω /0.5 w	WF 200 k/0,5
R224	Resistor, depos. carbon, variable	50 k Ω lin.	WS 7126/50 k
R225	Resistor, depos. carbon	200 k Ω /0.25 w	WF 200 k/0,25
R228	Resistor, depos. carbon	1 k Ω /0.25 w	WF 1 k/0,25
R229	Resistor, depos. carbon	500 k Ω /0.5 w	WF 500 k/0,5
R230	Resistor, depos. carbon	500 k Ω /0.25 w	WF 500 k/0,25
R231	Resistor, depos. carbon	500 k Ω /0.25 w	WF 500 k/0,25
R232	Resistor, depos. carbon	200 Ω /0.25 w	WF 200/0,25
R233	Resistor, depos. carbon	50 k Ω /0.25 w	WF 50 k/0,25
R234	Resistor, depos. carbon	200 k Ω /0.25 w	WF 200 k/0,25
R235	Resistor, depos. carbon	200 Ω /0.25 w	WF 200/0,25
R236	Resistor, depos. carbon	20 k Ω /0.5 w	WF 20 k/0,5
R237	Resistor, depos. carbon	500 Ω /0.25 w	WF 500/0,25
R238	Resistor, depos. carbon	100 k Ω /0.25 w	WF 100 k/0,25
R239	Resistor, depos. carbon	200 Ω /0.25 w	WF 200/0,25
R240	Resistor, depos. carbon	60 Ω /0.25 w	WF 60/0,25
R241	Resistor, depos. carbon	60 k Ω /0.5 w	WF 60 k/0,5
R242	Resistor, depos. carbon	100 Ω /0.25 w	WF 100/0,25
R243	Resistor, depos. carbon	50 k Ω /0.1 w	WFA 50 k/0,1
R244	Resistor, depos. carbon	160 k Ω /0.25 w	WF 160 k/0,25
R245	Resistor, depos. carbon	2 M Ω /0.25 w	WF 2 M/0,25
R246	Resistor, depos. carbon	2.5 k Ω /0.25 w	WF 2,5 k/0,25

Ref. No.	Designation	Ratings	R&S Stock No.
R247	Resistor, depos. carbon	100 k Ω /0.25 w	WF 100 k/0,25
R248	Resistor, depos. carbon	100 k Ω /0.25 w	WF 100 k/0,25
R249	Resistor, depos. carbon	300 k Ω /0.25 w	WF 300 k/0,25
R250	Resistor, depos. carbon	200 k Ω /0.25 w	WF 200 k/0,25
R251	Resistor, depos. carbon	500 k Ω /0.25 w	WF 500 k/0,25
R252	Resistor, depos. carbon	1 M Ω /0.25 w	WF 1 M/0,25
R253	Resistor, depos. carbon	500 k Ω /0.5 w	WF 500 k/0,5
R254	Resistor, depos. carbon, variable	25 k Ω lin.	WS 7126/25 k
R255	Resistor, depos. carbon	300 Ω /0.5 w	WFO 300/0,5
R256	Resistor, depos. carbon	800 Ω /0.5 w	WFO 800/0,5
R257	Resistor, depos. carbon	4 k Ω /0.5 w	WFO 4 k/0,5
R258	Resistor, wire-wound, variable	100 Ω lin.	WR-4 F/100
R259	Resistor, depos. carbon, variable	10 k Ω lin.	WS 9122 F/10 k
R260	Resistor, depos. carbon	1.6 k Ω /0.5 w	WF 1,6 k/0,5
R261	Resistor, depos. carbon, variable	2.5 k Ω lin.	WS 9122 F/2,5 k
R262	Resistor, depos. carbon, variable	2.5 k Ω lin.	WS 9122 F/2,5 k
R263	Resistor, depos. carbon, variable	2.5 k Ω lin.	WS 9122 F/2,5 k
R264	Resistor, depos. carbon, variable	2.5 k Ω lin.	WS 9122 F/2,5 k
R265	Resistor, VDR		WUC 41031
R266	Resistor, VDR		WUC 31241
R267	Resistor, depos. carbon	500 Ω /0.25 w	WF 500/0,25
R268	Resistor, depos. carbon, variable	500 Ω lin.	WS 7126/500

Ref. No.	Designation	Ratings	R&S Stock No.
R269	Resistor, depos. carbon, variable	10 k Ω lin.	E 415 - 40.2/10 k
R270	Resistor, depos. carbon	1.06 k Ω $\pm 1\%$ /0.1 w	WFS 5/1,06 k/1/0,1
R271	Resistor, depos. carbon	6.8 Ω $\pm 1\%$ /0.1 w	WFS 5/6,8/1/0,1
R272	Resistor, depos. carbon	1.06 k Ω $\pm 1\%$ /0.1 w	WFS 5/1,06 k/1/0,1
R273	Resistor, depos. carbon	1.06 k Ω $\pm 1\%$ /0.1 w	WFS 5/1,06 k/1/0,1
R274	Resistor, depos. carbon	6.8 Ω $\pm 1\%$ /0.1 w	WFS 5/6,8/1/0,1
R275	Resistor, depos. carbon	1.06 k Ω $\pm 1\%$ /0.1 w	WFS 5/1,06 k/1/0,1
R276	Resistor, depos. carbon	1.06 k Ω $\pm 1\%$ /0.1 w	WFS 5/1,06 k/1/0,1
R277	Resistor, depos. carbon	6.8 Ω $\pm 1\%$ /0.1 w	WFS 5/6,8/1/0,1
R278	Resistor, depos. carbon	1.06 k Ω $\pm 1\%$ /0.1 w	WFS 5/1,06 k/1/0,1
R279	Resistor, depos. carbon	1.06 k Ω $\pm 1\%$ /0.1 w	WFS 5/1,06 k/1/0,1
R280	Resistor, depos. carbon	6.8 Ω $\pm 1\%$ /0.1 w	WFS 5/6,8/1/0,1
R281	Resistor, depos. carbon	1.06 k Ω $\pm 1\%$ /0.1 w	WFS 5/1,06 k/1/0,1
R282	Resistor, depos. carbon	1.06 k Ω $\pm 1\%$ /0.1 w	WFS 5/1,06 k/1/0,1
R283	Resistor, depos. carbon	6.8 Ω $\pm 1\%$ /0.1 w	WFS 5/6,8/1/0,1
R284	Resistor, depos. carbon	1.06 k Ω $\pm 1\%$ /0.1 w	WFS 5/1,06 k/1/0,1
R285	Resistor, depos. carbon	1.06 k Ω $\pm 1\%$ /0.1 w	WFS 5/1,06 k/1/0,1
R286	Resistor, depos. carbon	6.8 Ω $\pm 1\%$ /0.1 w	WFS 5/6,8/1/0,1
R287	Resistor, depos. carbon	1.06 k Ω $\pm 1\%$ /0.1 w	WFS 5/1,06 k/1/0,1
R288	Resistor, depos. carbon	1.06 k Ω $\pm 1\%$ /0.1 w	WFS 5/1,06 k/1/0,1
R289	Resistor, depos. carbon	6.8 Ω $\pm 1\%$ /0.1 w	WFS 5/6,8/1/0,1
R290	Resistor, depos. carbon	1.06 k Ω $\pm 1\%$ /0.1 w	WFS 5/1,06 k/1/0,1
R291	Resistor, depos. carbon	1.06 k Ω $\pm 1\%$ /0.1 w	WFS 5/1,06 k/1/0,1
R292	Resistor, depos. carbon	6.8 Ω $\pm 1\%$ /0.1 w	WFS 5/6,8/1/0,1
R293	Resistor, depos. carbon	1.06 k Ω $\pm 1\%$ /0.1 w	WFS 5/1,06 k/1/0,1
R294	Resistor, depos. carbon	1.06 k Ω $\pm 1\%$ /0.1 w	WFS 5/1,06 k/1/0,1

Ref. No.	Designation	Ratings	R&S Stock No.
R295	Resistor, depos. carbon	6.8 Ω $\pm 1\%$ /0.1 w	WFS 5/6,8/1/0,1
R296	Resistor, depos. carbon	1.06 k Ω $\pm 1\%$ /0.1 w	WFS 5/1,06 k/1/0,1
R297	Resistor, depos. carbon	1.06 k Ω $\pm 1\%$ /0.1 w	WFS 5/1,06 k/1/0,1
R298	Resistor, depos. carbon	6.8 Ω $\pm 1\%$ /0,1 w	WFS 5/6,8/1/0,1
R299	Resistor, depos. carbon	1.06 k Ω $\pm 1\%$ /0.1 w	WFS 5/1,06 k/1/0,1
R300	Resistor, depos. carbon	300 Ω $\pm 1\%$ /0.25 w	WFK 613/300/1/0,25
R301	Resistor, depos. carbon	15 Ω $\pm 1\%$ /0.25 w	WFK 613/15/1/0,25
R302	Resistor, depos. carbon	50 k Ω /0.5 w	WF 50 k/0,5
R303	Resistor, depos. carbon	50 k Ω /0.25 w	WF 50 k/0,25
R304	Resistor, depos. carbon	15 Ω $\pm 1\%$ /0.25 w	WFK 613/15/1/0,25
R305	Resistor, depos. carbon	125 Ω /0.1 w	WF 125/0,1
R306	Resistor, depos. carbon	400 Ω /0.1 w	WF 400/0,1
R307	Resistor, depos. carbon, variable	500 Ω lin.	WS 9122 F/500
R308	Resistor, depos. carbon	125 Ω /0.1 w	WF 125/0,1
R309	Resistor, depos. carbon	800 Ω /0.1 w	WF 800/0,1
RL1	Lamp, scale		RL 165 S
RL2	Lamp, scale		RL 165 S
RL3	Lamp, control		RL 215
Rs1	Relay		ELW 4244-54
Rs2	Relay		ELW 4244-54
Rs3	Relay		ELW 4244-54
Rs4	Relay		ELW 4244-54
Rs5	Relay		ELW 4244-54
Rs6	Relay		ELW 4244-54
Rs7	Relay		ELW 4244-54
Rs8	Relay		ELW 4244-54

Ref. No.	Designation	Ratings	R&S Stock No.
R01	Triode, twin		ECC 81
R02	Pentode, wideband		E 180 F
R03	Pentode, wideband		E 180 F
R04	Pentode, wideband		E 180 F
R05	Pentode, wideband		E 180 F
R06	Pentode, wideband		E 180 F
R07	Pentode, wideband		E 180 F
R08	Triode, twin		E 88 CC
R09	Triode, twin		E 88 CC
R010	Triode, twin		ECC 81
R011	Triode, twin		ECC 81
R012	Pentode, AF		EF 804 S
R013	Picture tube		MW 36 - 44 or 14 M 10 P 4
R014	Pentode, AF		EF 86
R015	Triode, twin		ECC 81
R016	Triode, twin		ECC 81
R017	Triode, twin		EAA 91
R018	Triode, twin		ECC 81
R019	Pentode, output		EL 84
R020	Pentode, output		EF 86
R021	Triode, twin		ECC 81
R022	Triode, twin		ECC 81
R023	Triode, twin		ECC 81
R024	Triode, twin		ECC 81
R025	Triode, twin		ECC 81
R026	Triode, twin		ECC 81
R027	Pentode, wideband		E 180 F
R028	Pentode, wideband		E 180 F

Ref. No.	Designation	Ratings	R&S Stock No.
Rö29	Duo-triode		ECC 81
Rö30	Pentode, output		EL 86
Rö31	Pentode, output		EL 86
Rö32	Pentode, AF		EF 804 S
Rö33	Reference tube		85 A 2
Rö34	Reference tube		85 A 2
Rö35	Pentode, output		EL 95
S1	Attenuator, 1-db		4244 - 31
S2	Attenuator, 10-db		4244 - 30
S3	Switch		SRW 14320
S4	Switch		SRW 14220
S5	Switch		SRW 14220
S6	Switch		SRW 14220
S7	Switch, power (combination)		SRK 1
Si1	Fuse		1 C DIN 41571
Tr1	Transformer, power		BV 104 501
Tr2	Transformer		BV 112 114
T1	Transistor		GT/OC 604 spec.
T2	Transistor		GT/OC 604 spec.
T3	Transistor		GT/CTP 1109

Guarantee

Rohde & Schwarz guarantee

F O R O N E Y E A R

each instrument manufactured and sold by them to be free from defects in material and workmanship, subject to clause 5 of their terms of delivery and payment.

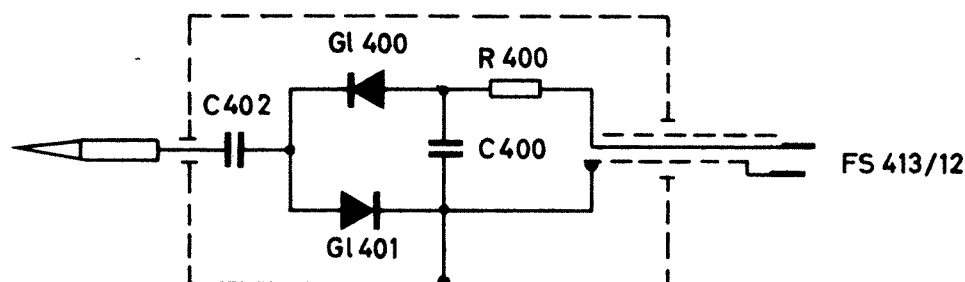
This guarantee does not imply the right to rescind a sale or demand a reduction in purchase price. The firm's obligation under this guarantee is limited to the repair or replacement of the defective part or parts, provided the claim is asserted in writing immediately, or within one week at the latest, after discovery of the defect. The part or parts shall be returned to the factory, with transportation charges prepaid, within one week from the instruction by the firm to do so. The return charges shall likewise be covered by the purchaser. The firm does not assume any liability for damage resulting directly or indirectly from the defect. The guarantee shall be void if the part or parts have been tampered with.

The seals of the instrument shall be undamaged. Rohde & Schwarz guarantee valves for which the purchaser has not received the certificate of guarantee of the manufacturer. Defective valves which are held to be covered by this guarantee shall be returned to the factory for examination. The following details shall be specified:

Number, date and reference of the invoice;
type and serial number (FNr.) of the instrument;
specification of valve defect.

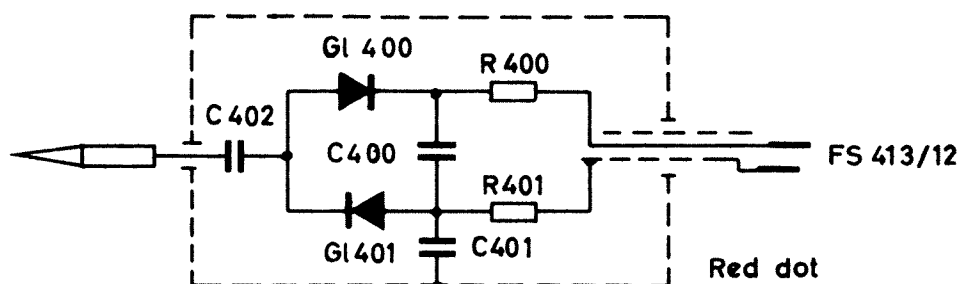
R O H D E & S C H W A R Z · M Ü N C H E N

Circuit Diagram and Table of Replaceable Parts for RF Diode Probe BN 42443

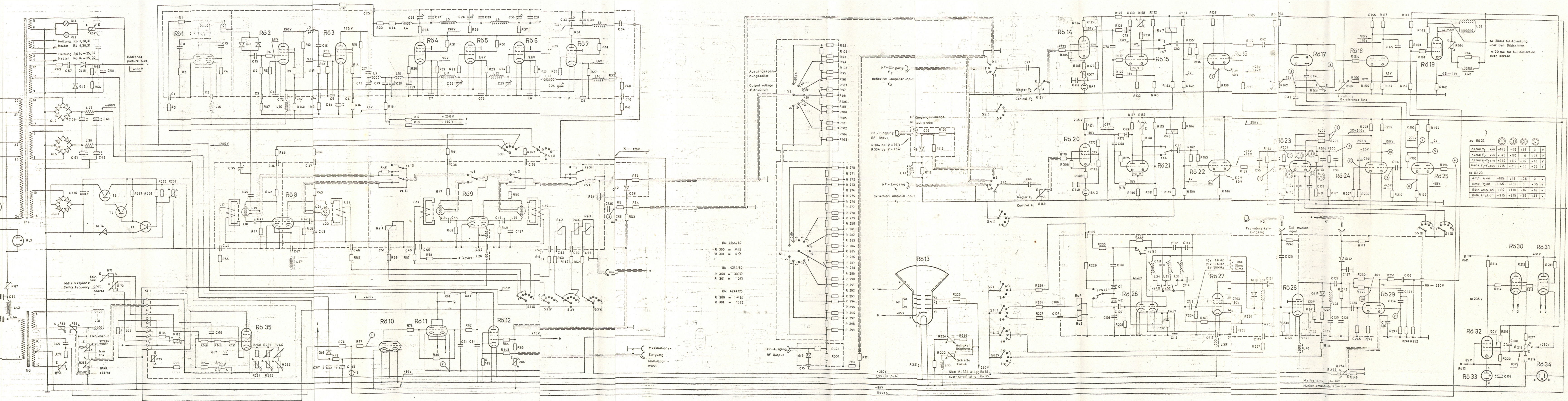
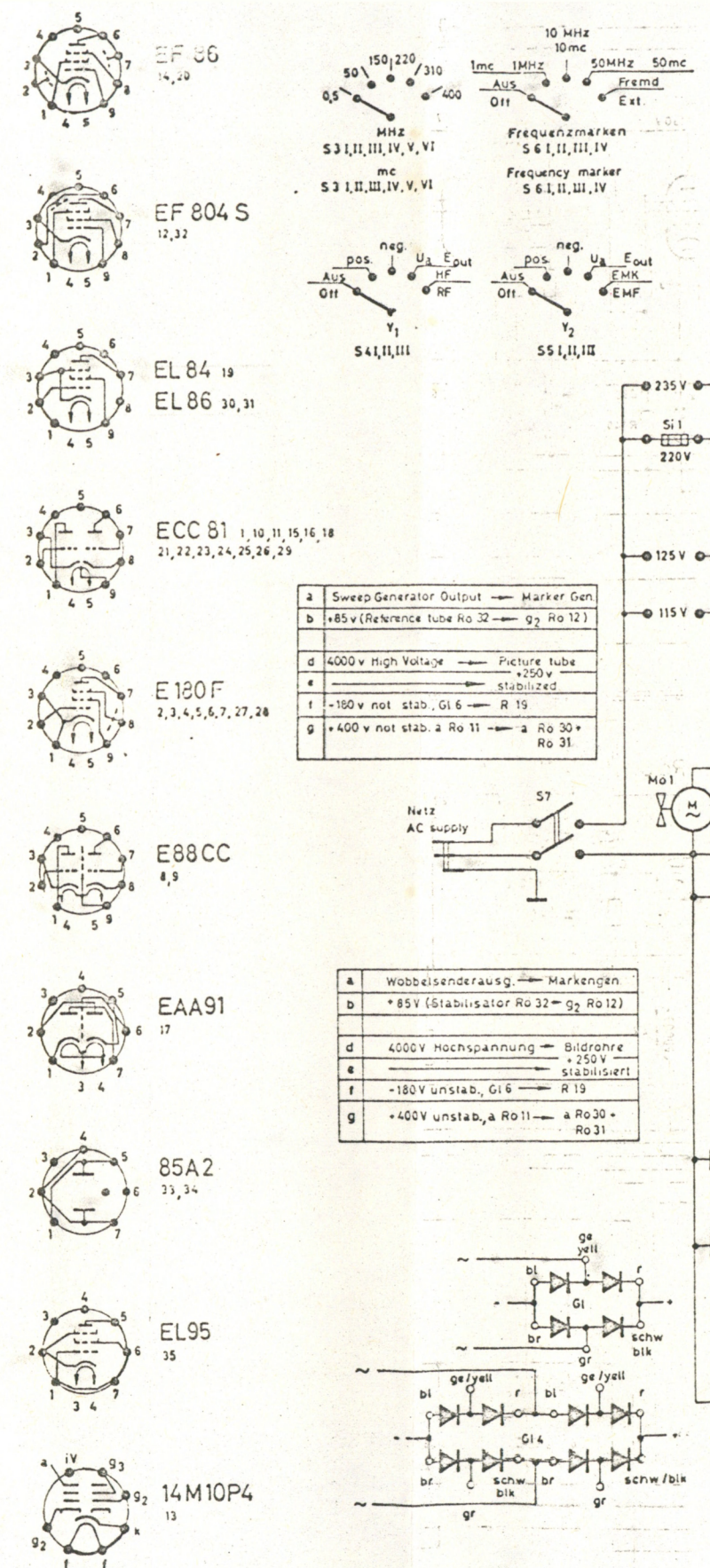


Ref. No.	Designation	Ratings	R&S Stock No.
C400	Capacitor, ceramic	220 pf	CCG 91/220
C402	Capacitor, ceramic	220 pf	CCG 91/220
G1400	Diode, germanium		GK 2501
G1401	Diode, germanium		GK 2501
R400	Resistor, depos. carbon	12.5 k Ω /0.05 w	WF 12,5 k/0,05

Circuit Diagram and Table of Replaceable Parts for RF Diode Probe BN 42444



Ref. No.	Designation	Ratings	R&S Stock No.
C400	Capacitor, ceramic	220 pf	CCG 91/220
C401	Capacitor, ceramic	2200 pf	CCG 91/2200
C402	Capacitor, ceramic	220 pf	CCG 91/220
G1400	Diode, germanium		GK 2501
G1401	Diode, germanium		GK 2501
R400	Resistor, depos. carbon	12.5 k Ω /0.05 w	WF 12,5 k/0,05
R401	Resistor, depos. carbon	30 Ω /0.05 w	WF 30/0,05



Anmerkung
 Die 8 Relais Rs1 ... Rs8 werden nicht mehr aus der 205-V-Spannung gespeist, sondern liegen über ihre zugehörigen Schalter direkt am Widerstand R258 der durch T3-T2-T1 stabilisierter Heizspannungsquelle. Die Vorwiderstände R59, R60, R62, R153, R187, R189, R226 und R227 entfallen.

Note
 The 8 relays Rs1 incl. Rs8 are taken off the 205 V B₊ supply. They are now directly connected through the corresponding switches to the output resistor R258 of the stabilized filament-voltage source T3-T2-T1. Resistors R59, R60, R62, R153, R187, R189, R226 and R227 are dropped together.

Stromlauf
Circuit Diagram
Type SWOB BN 4244 /...

Elektronische
Präzision



MIT LUFTPOST
PAR AVION
BY AIR MAIL

ROHDE & SCHWARZ

Messrs.
Zimmermann Electronic Research
8448 North Harding Avenue
Skokie, Illinois 60076/ USA

Zimmermann Electronic Research
8448 North Harding Avenue
Skokie, Illinois 60076/ USA



ROHDE & SCHWARZ

Drahtwort Cable	Fernsprecher Phone	Fernschreiber Teletype	Bahnhof für alle Güter Goods station
rohdeschwarz muenchen	0 89 München 41 29-1	523 703 rus d	München-Ostbahnhof
Bankverbindungen Bankers	Bankleitzahl Bankrouting No.	Konto Nr. Account No.	S.W.I.F.T. Adresse S.W.I.F.T. Address
Deutsche Bank, München	(BLZ 700 700 10)	20/31 468	DEUT DE MM
Bayerische Vereinsbank, München	(BLZ 700 202 70)	360	BVBE DE MM
Hypobank, München	(BLZ 700 200 16)	4 280 107 706	HYPO DE MM
Postscheckkonto Postal Check Account	Bankleitzahl Bankrouting No.	Konto Nr. Account No.	
Postscheckamt, München	(BLZ 700 100 80)	496 75-809	

Proforma Invoice no.065 197

Ihre Bestellung vom, Nr., Zeichen/Your Order No., Ref., Date Dec.5,1977	geliefert am delivered on	ME-Schlüssel/ Unit code 1 = m 5 = kg 7 = Stück/Piece 8 = Paar/Pair 9 = Satz/Set	Bei Schriftwechsel und Zahlung bitte angeben For reply and remittance please state	Kunden-Nr. Customer-No. 80200 - - - -	Auftrags-Nr. Order-No.	Rechnungs-Nr. Invoice-No.	Datum Date Jan.4,1978	Blatt-Nr. Sheet-No. 1
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Versandanschrift Consignee's address	Versandart/Mode of transport by airparcel post	Netto 1,300 32x 27x 6 1 box RS 40832	kg 1,500	Brutto
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Pos. Item	Typ/Familie und Bezeichnung Type/Family and Designation	Sach-Nr. Stock No.	Fertigungs-Nr. Serial No.	Menge Quantity	ME UC	Einzelpreis Unit price	Gesamtpreis Subtotal	Lief.-Monat Delivery month
1)	English Instruction book for type SWOB BN 4244/2/75 <u>Delivery free of charge</u>		1944/18	1		Value: DM 2,-- =====		
						For customs purposes only		

Zahlungsbedingungen/Terms of payment	Warenwert Goods/Services	MwSt %	MwSt DM	Rechnungssumme Grand total

Rohde & Schwarz
ROHDE & SCHWARZ

Zimmermann Electronic Research
8448 North Harding Avenue
Skokie, Illinois 60076/ USA



ROHDE & SCHWARZ

Drahtwort Cable	Fernsprecher Phone	Fernschreiber Teletype	Bahnhof für alle Güter Goods station
rohdeschwarz muenchen	0 89 München 41 29-1	523 703 rus d	München-Ostbahnhof
Bankverbindungen Bankers	Bankleitzahl Bankrouting No.	Konto Nr. Account No.	S.W.I.F.T. Adresse S.W.I.F.T. Address
Deutsche Bank, München	(BLZ 700 700 10)	20/31 466	DEUT DE MM
Bayerische Vereinsbank, München	(BLZ 700 202 70)	360	BVBE DE MM
Hypobank, München	(BLZ 700 200 16)	4 280 107 706	HYPO DE MM
Postscheckkonto Postal Check Account	Bankleitzahl Bankrouting No.	Konto Nr. Account No.	
Postscheckamt, München	(BLZ 700 100 80)	496 75-809	

packing list
Proforma Invoice no.065 197

Ihre Bestellung vom, Nr., Zeichen/Your Order No., Ref., Date Dec.5,1977	geliefert am delivered on	ME-Schlüssel/Unit code 1 = m 5 = kg 7 = Stück/Piece 8 = Paar/Pair 9 = Satz/Set	Bei Schriftwechsel und Zahlung bitte angeben For reply and remittance please state	Kunden-Nr. Customer-No. 80200 - - - -	Auftrags-Nr. Order-No.	Rechnungs-Nr. Invoice-No.	Datum Date Jan.4,1978	Blatt-Nr. Sheet-No. 1
Versandanschrift Consignee's address			Versandart/ Mode of transport by air parcel post		Netto kg Brutto 1,300 1,500 32x 27x 6 1 box RS 40832			

Pos. Item	Typ/Familie und Bezeichnung Type/Family and Designation	Sach-Nr. Stock No.	Fertigungs-Nr. Serial No.	Menge Quantity	ME UC	Einzelpreis Unit price	Gesamtpreis Subtotal	Lief.-Monat Delivery month
1)	English Instruction book for type SWOB BN 4244/2/75 <u>Delivery free of charge</u>		1944/18	1		Value: =====	DM 2,--	
						For customs purposes only		

Zahlungsbedingungen/Terms of payment	Warenwert Goods/ Services	MwSt %	MwSt DM	Rechnungssumme Grand total
	ROHDE & SCHWARZ			

ROHDE & SCHWARZ

8 MÜNCHEN 80 • POSTFACH 801469

6019